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ART. I.—*Contributions to Electricity and Magnetism. On Electro-Dynamic Induction; by* JOSEPH HENRY, Professor of Natural Philosophy in the College of New Jersey, Princeton. Read November 2, 1838.*

INTRODUCTION.

1. SINCE my investigations in reference to the influence of a spiral conductor, in increasing the intensity of a galvanic current, were submitted to the Society, the valuable paper of Dr. Faraday, on the same subject, has been published, and also various modifications of the principle have been made by Sturgeon, Masson, Page and others, to increase the effects. The spiral conductor has likewise been applied by Cav. Antonori to produce a spark by the action of a thermo-electrical pile; and Mr. Watkins has succeeded in exhibiting all the phenomena of hydro-electricity by the same means. Although the principle has been much extended by the researches of Dr. Faraday, yet I am happy to state that the results obtained by this distinguished philosopher are not at variance with those given in my paper.

2. I now offer to the Society a new series of investigations in the same line, which I hope may also be considered of sufficient importance to merit a place in the Transactions.

3. The primary object of these investigations was to discover, if possible, inductive actions in common electricity analogous to

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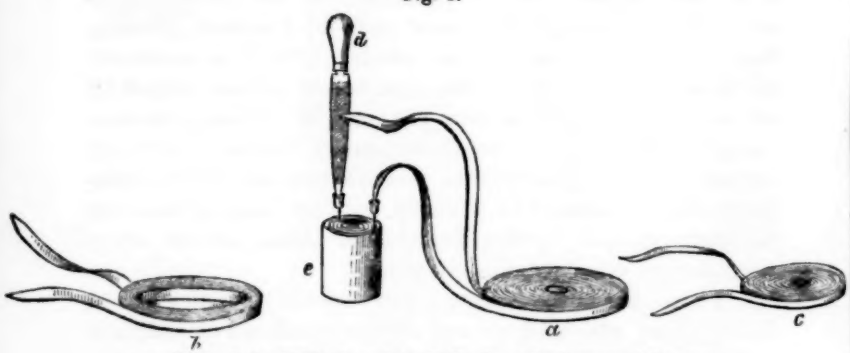
those found in galvanism. For this purpose a series of experiments was commenced in the spring of 1836, but I was at that time diverted, in part, from the immediate object of my research, by a new investigation of the phenomenon known in common electricity by the name of the lateral discharge. Circumstances prevented my doing any thing further, in the way of experiment, until April last, when most of the results which I now offer to the Society were obtained. The investigations are not as complete, in several points, as I could wish, but as my duties will not permit me to resume the subject for some months to come, I therefore present them as they are; knowing, from the interest excited by this branch of science in every part of the world, that the errors which may exist will soon be detected, and the truths be further developed.

4. The experiments are given nearly in the order in which they were made; and in general they are accompanied by the reflections which led to the several steps of the investigation. The whole series is divided, for convenience of arrangement, into six sections, although the subject may be considered as consisting, principally, of two parts. The first, relating to a new examination of the induction of galvanic currents; and the second, to the discovery of analogous results in the discharge of ordinary electricity.*

Fig. 1.



a coil No. 1, *b* coil No. 2, and *c* coil No. 3; *e* the battery, *d* the rasp.

5. The principal articles of apparatus used in the experiments, consist of a number of flat coils of copper riband, which will be

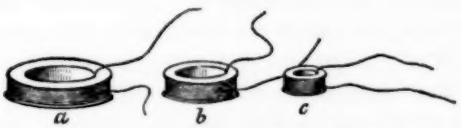
* The several paragraphs are, for convenience of reference, numbered in succession, from the first to the last, after the mode adopted by Dr. Faraday.

designated by the names of coil No. 1, coil No. 2, &c.; also of several coils of long wire; and these, to distinguish them from the ribands, will be called helix No. 1, helix No. 2, &c.

6. Coil No. 1 is formed of thirteen pounds of copper plate, one inch and a half wide and ninety-three feet long. It is well covered with two coatings of silk, and was generally used in the form represented in Fig. 1, which is that of a flat spiral, sixteen inches in diameter. It was however sometimes formed into a ring of larger diameter, as is shown in Fig. 4, Section III.

7. Coil No. 2 is also formed of copper plate, of the same width and thickness as coil No. 1. It is, however, only sixty feet long. Its form is shown at *b*, Fig 1. The opening at the centre is sufficient to admit helix No. 1. Coils No. 3, 4, 5, 6, &c., are all about sixty feet long, and of copper plate of the same thickness, but of half the width of coil No. 1.

Fig. 2.



a helix No. 1, *b* helix No. 2, *c* helix No. 3.

8. Helix No. 1 consists of sixteen hundred and sixty yards of copper wire, $\frac{1}{4\frac{1}{9}}$th of an inch in diameter; No. 2, of nine hundred and ninety yards; and No. 3, of three hundred and fifty yards, of the same wire. These helices are shown in Fig. 2, and are so adjusted in size as to fit into each other; thus forming one long helix of three thousand yards: or, by using them separately, and in different combinations, seven helices of different lengths. The wire is covered with cotton thread, saturated with bees' wax, and between each stratum of spires a coating of silk is interposed.

9. Helix No. 4 is shown at *a*, Fig. 4, Section III; it is formed of five hundred and forty-six yards of wire, $\frac{1}{4\frac{1}{9}}$th of an inch in diameter, the several spires of which are insulated by a coating of cement. Helix No. 5 consists of fifteen hundred yards of silvered copper wire, $\frac{1}{7\frac{1}{23}}$th of an inch in diameter, covered with cotton, and is of the form of No. 4.

10. Besides these I was favored with the loan of a large spool of copper wire, covered with cotton, $\frac{1}{7\frac{1}{6}}$th of an inch in diameter,

and five miles long. It is wound on a small axis of iron, and forms nearly a solid cylinder of wire, eighteen inches long, and thirteen in diameter.

11. For determining the direction of induced currents, a magnetizing spiral was generally used, which consists of about thirty spires of copper wire, in the form of a cylinder, and so small as just to admit a sewing needle into the axis.

12. Also a small horse-shoe is frequently referred to, which is formed of a piece of soft iron, about three inches long, and $\frac{3}{4}$ths of an inch thick; each leg is surrounded with about five feet of copper bell wire. This length is so small, that only a current of electricity of considerable quantity can develop the magnetism of the iron. The instrument is used for indicating the existence of such a current.

13. The battery used in most of the experiments is shown in Fig. 1. It is formed of three concentric cylinders of copper, and two interposed cylinders of zinc. It is about eight inches high, five inches in diameter, and exposes about one square foot and three quarters of zinc surface, estimating both sides of the metal. In some of the experiments a larger battery was used, weakly charged, but all the results mentioned in the paper, except those with a Cruickshank trough, can be obtained with one or two batteries of the above size, particularly if excited by a strong solution. The method of interrupting the circuit of the conductor by means of a rasp, *b*, is shown in the same Figure.

SECTION I.

Conditions which influence the Induction of a Current on itself.

14. The phenomenon of the spiral conductor is at present known by the name of the induction of a current on itself, to distinguish it from the induction of the secondary current, discovered by Dr. Faraday. The two, however, belong to the same class, and experiments render it probable that the spark given by the long conductor is, from the natural electricity of the metal, disturbed for an instant by the induction of the primary current. Before proceeding to the other parts of these investigations, it is important to state the results of a number of preliminary experiments, made to determine more definitely the conditions which influence the action of the spiral conductor.

15. When the electricity is of low intensity, as in the case of the thermo-electrical pile, or a large single battery weakly excited with dilute acid, the flat riband coil No. 1, ninety-three feet long, is found to give more brilliant deflagrations, and louder snaps from a surface of mercury, than any other form of conductor. The shocks, with this arrangement, are, however, very feeble, and can be felt only in the fingers or through the tongue.

16. The induced current in a short conductor, which thus produces deflagration, but not shocks, may, for distinction, be called one of quantity.

17. When the length of the coil is increased, the battery continuing the same, the deflagrating power decreases, while the intensity of the shock continually increases. With five riband coils, making an aggregate length of three hundred feet, and the small battery, Fig. 1, the deflagration is less than with coil No. 1, but the shocks are more intense.

18. There is, however, a limit to this increase of intensity of the shock, and this takes place when the increased resistance or diminished conduction of the lengthened coil begins to counteract the influence of the increasing length of the current. The following experiment illustrates this fact. A coil of copper wire $\frac{1}{16}$th of an inch in diameter, was increased in length by successive additions of about thirty two feet at a time. After the first two lengths, or sixty four feet, the brilliancy of the spark began to decline, but the shocks constantly increased in intensity, until a length of five hundred and seventy five feet was obtained, when the shocks also began to decline. This was then the proper length to produce the maximum effect with a single battery, and a wire of the above diameter.

19. When the intensity of the electricity of the battery is increased, the action of the short riband coil decreases. With a Cruickshank's trough of sixty plates, four inches square, scarcely any peculiar effect can be observed, when the coil forms a part of the circuit. If however the length of the coil be increased in proportion to the intensity of the current, then the inductive influence becomes apparent. When the current, from ten plates of the above mentioned trough, was passed through the wire of the large spool, (10,) the induced shock was too severe to be taken through the body. Again, when a small trough of twenty five one inch plates, which alone would give but a very feeble shock,

was used with helix No. 1, an intense shock was received from the induction, when the contact was broken. Also a slight shock in this arrangement is given when the contact is formed, but it is very feeble in comparison with the other. The spark, however, with the long wire and compound battery is not as brilliant as with the single battery and the short riband coil.

20. When the shock is produced from a long wire, as in the last experiments, the size of the plates of the battery may be very much reduced, without a corresponding reduction of the intensity of the shock. This is shown in an experiment with the large spool of wire, (10.) A very small compound battery was formed of six pieces of copper bell wire, each about one inch and a half long, and an equal number of pieces of zinc of the same size. When the current from this was passed through the five miles of the wire of the spool, the induced shock was given at once to twenty six persons, joining hands. This astonishing effect places the action of a coil in a striking point of view.

21. With the same spool and the single battery used in the former experiments, no shock, or at most only a very feeble one, could be obtained. A current, however, was found to pass through the whole length, by its action on the galvanometer; but it was not sufficiently powerful to induce a current which could counteract the resistance of so long a wire.

22. The induced current in these experiments may be considered as one of *considerable intensity*, and *small quantity*.

23. The form of the coil has considerable influence on the intensity of the action. In the experiments of Dr. Faraday, a long cylindrical coil of thick copper wire, inclosing a rod of soft iron, was used. This form produces the greatest effect when magnetic reaction is employed; but in the case of simple galvanic induction, I have found the form of the coils and helices represented in the figures most effectual. The several spires are more nearly approximated, and therefore they exert a greater mutual influence. In some cases, as will be seen hereafter, the ring form, shown in Fig. 4, is most effectual.

24. In all cases the several spires of the coil should be well insulated, for although in magnetizing soft iron, and in analogous experiments, the touching of two spires is not attended with any great reduction of action; yet in the case of the induced current, as will be shown in the progress of these investigations, a single

contact of two spires is sometimes sufficient to neutralize the whole effect.

25. It must be recollected that all the experiments with these coils and helices, unless otherwise mentioned, are made without the reaction of iron temporarily magnetized; since the introduction of this would, in some cases, interfere with the action, and render the results more complex.

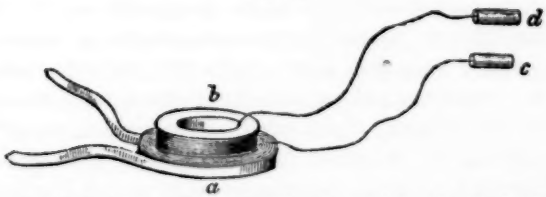
SECTION II.

Conditions which influence the production of Secondary Currents.

26. The secondary currents, as it is well known, were discovered in the induction of magnetism and electricity, by Dr. Faraday, in 1831. But he was at that time urged to the exploration of new, and apparently richer veins of science, and left this branch to be farther traced by others. Since then, however, attention has been almost exclusively directed to one part of the subject, namely, the induction from magnetism, and the perfection of the magneto-electrical machine. And I know of no attempts, except my own, to review and extend the purely electrical part of Dr. Faraday's admirable discovery.

27. The energetic action of the flat coil, in producing the induction of a current on itself, led me to conclude that it would also be the most proper means for the exhibition and study of the phenomena of the secondary galvanic currents.

Fig. 3.



a coil No. 1, *b* helix No. 1, and *c*, *d*, handles for receiving the shock. The plate of glass is omitted in the drawing.

28. For this purpose coil No. 1 was arranged to receive the current from the small battery, and coil No. 2 placed on this, with a plate of glass interposed to insure perfect insulation; as often as the circuit of No. 1 was interrupted, a powerful secondary current was induced in No. 2. The arrangement is the same as that ex-

hibited in Fig. 3, with the exception that in this the compound helix is represented as receiving the induction, instead of coil No. 2.

29. When the ends of the second coil were rubbed together, a spark was produced at the opening. When the same ends were joined by the magnetizing spiral (11,) the inclosed needle became strongly magnetic. Also when the secondary current was passed through the wires of the iron horse-shoe, (12,) magnetism was developed; and when the ends of the second coil were attached to a small decomposing apparatus, of the kind which accompanies the magneto-electrical machine, a stream of gas was given off at each pole. The shock, however, from this coil is very feeble, and can scarcely be felt above the fingers.

30. This current has therefore the properties of one of moderate intensity, but considerable quantity.

31. Coil No. 1 remaining as before, a longer coil, formed by uniting Nos. 3, 4 and 5, was substituted for No. 2. With this arrangement, the spark produced when the ends were rubbed together, was not as brilliant as before; the magnetizing power was much less; decomposition was nearly the same, but the shocks were more powerful, or, in other words, the intensity of the induced current was increased by an increase of the length of the coil, while the quantity was apparently diminished.

32. A compound helix, formed by uniting Nos. 1 and 2, and therefore containing two thousand six hundred and fifty yards of wire, was next placed on coil No. 1. The weight of this helix happened to be precisely the same as that of coil No. 2, and hence the different effects of the same quantity of metal in the two forms of a long and short conductor, could be compared. With this arrangement, the magnetizing effects, with the apparatus before mentioned, disappeared. The sparks were much smaller, and also the decomposition less, than with the short coil; but the shock was almost too intense to be received with impunity, except through the fingers of one hand. A circuit of fifty six of the students of the senior class, received it at once from a single rupture of the battery current, as if from the discharge of a Leyden jar weakly charged. The secondary current in this case was one of small quantity, but of great intensity.

33. The following experiment is important in establishing the fact of a limit to the increase of the intensity of the shock, as

well as the power of decomposition, with a wire of a given diameter. Helix No. 5, which consists of wire only $\frac{1}{125}$th of an inch in diameter, was placed on coil No. 2, and its length increased to about seven hundred yards. With this extent of wire, neither decomposition nor magnetism could be obtained, but shocks were given of a peculiarly pungent nature; they did not, however, produce much muscular action. The wire of the helix was further increased to about fifteen hundred yards; the shock was now found to be scarcely perceptible in the fingers.

34. As a counterpart to the last experiment, coil No. 1 was formed into a ring of sufficient internal diameter to admit the great spool of wire, (10,) and with the whole length of this (which, as has before been stated, is five miles) the shock was found so intense as to be felt at the shoulder, when passed only through the forefinger and thumb. Sparks and decomposition were also produced, and needles rendered magnetic. The wire of this spool is $\frac{1}{16}$th of an inch thick, and we therefore see from this experiment, that by increasing the diameter of the wire, its length may also be much increased, with an increased effect.

35. The fact (33) that the induced current is diminished by a further increase of the wire, after a certain length has been attained, is important in the construction of the magneto-electrical machine, since the same effect is produced in the induction of magnetism. Dr. Goddard of Philadelphia, to whom I am indebted for coil No. 5, found that when its whole length was wound on the iron of a temporary magnet, no shocks could be obtained. The wire of the machine may therefore be of such a length, relative to its diameter, as to produce shocks, but no decomposition; and if the length be still further increased, the power of giving shocks may also become neutralized.

36. The inductive action of coil No. 1, in the foregoing experiments, is precisely the same as that of a temporary magnet in the case of the magneto-electrical machine. A short thick wire around the armature gives brilliant deflagrations, but a long one produces shocks. This fact, I believe, was first discovered by my friend Mr. Saxton, and afterwards investigated by Sturgeon and Lentz.

37. We might, at first sight, conclude, from the perfect similarity of these effects, that the currents which, according to the theory of Ampere, exist in the magnet, are like those in the short

coil, of great quantity and feeble intensity; but succeeding experiments will show that this is not necessarily the case.

38. All the experiments given in this section have thus far been made with a battery of a single element. This condition was now changed, and a Cruickshank trough of sixty pairs substituted. When the current from this was passed through the riband coil No. 1, no indication, or a very feeble one, was given of a secondary current in any of the coils or helices, arranged as in the preceding experiments. The length of the coil, in this case, was not commensurate with the intensity of the current from the battery. But when the long helix, No. 1, was placed instead of coil No. 1, a powerful inductive action was produced on each of the articles, as before.

39. First, helices No. 2 and 3 were united into one, and placed within helix No. 1, which still conducted the battery current. With this disposition a secondary current was produced, which gave intense shocks but feeble decomposition, and no magnetism in the soft iron horse-shoe. It was therefore one of intensity, and was induced by a battery current also of intensity.

40. Instead of the helix used in the last experiment for receiving the induction, one of the coils (No. 3) was now placed on helix No. 1, the battery remaining as before. With this arrangement the induced current gave no shocks, but it magnetized the small horse-shoe; and when the ends of the coil were rubbed together, produced bright sparks. It had therefore the properties of a current of quantity; and it was produced by the induction of a current, from the battery, of intensity.

41. This experiment was considered of so much importance, that it was varied and repeated many times, but always with the same result; it therefore establishes the fact *that an intensity current can induce one of quanity*, and, by the preceding experiments, the converse has also been shown, that *a quantity current can induce one of intensity.*

42. This fact appears to have an important bearing on the law of the inductive action, and would seem to favor the supposition that the lower coil, in the two experiments with the long and short secondary conductors, exerted the same amount of inductive force, and that in one case this was expended (to use the language of theory) in giving a great velocity to a small quantity of the fluid, and in the other in producing a slower motion in a larger

current; but in the two cases, were it not for the increased resistance to conduction in the longer wire, the quantity multiplied by the velocity would be the same. This, however, is as yet a hypothesis, but it enables us to conceive how intensity and quantity may both be produced from the same induction.

43. From some of the foregoing experiments we may conclude, that the quantity of electricity in motion in the helix is really less than in the coil, of the same weight of metal; but this may possibly be owing simply to the greater resistance offered by the longer wire. It would also appear, if the above reasoning be correct, that to produce the most energetic physiological effects, only a small quantity of electricity, moving with great velocity, is necessary.

44. In this and the preceding section, I have attempted to give only the general conditions which influence the galvanic induction. To establish the law, would require a great number of more refined experiments, and the consideration of several circumstances which would affect the results, such as the conduction of the wires, the constant state of the battery, the method of breaking the circuit with perfect regularity, and also more perfect means than we now possess of measuring the amount of the inductive action. All these circumstances render the problem very complex.

SECTION III.

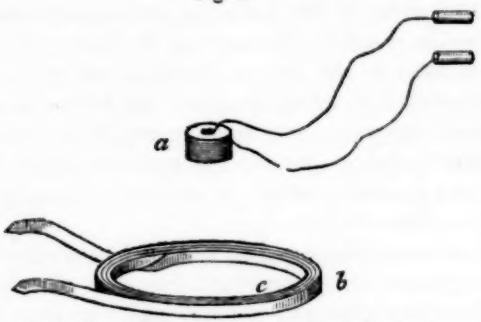
On the Induction of Secondary Currents at a distance.

45. In the experiments given in the two preceding sections, the conductor which received the induction, was separated from that which transmitted the primary current by the thickness only of a pane of glass; but the action from this arrangement was so energetic, that I was naturally led to try the effect at a greater distance.

46. For this purpose coil No. 1 was formed into a ring of about two feet in diameter, and helix No. 4 placed as is shown in the figure. When the helix was at the distance of about sixteen inches from the middle of the plane of the ring, shocks could be perceived through the tongue, and these rapidly increased in intensity as the helix was lowered, and when it reached the plane of the ring they were quite severe. The effect, however, was still greater when the helix was moved from the centre to the

inner circumference, as at *c*: but when it was placed without the ring, in contact with the outer circumference, at *b*, the shocks were very slight; and when placed within, but its axis at right angles to that of the ring, not the least effect could be observed.

Fig. 4.



a helix No. 4, *b* coil No. 1, in the form of a ring.

47. With a little reflection, it will be evident that this arrangement is not the most favorable for exhibiting the induction at a distance, since the side of the ring, for example, at *c*, tends to produce a current revolving in one direction in the near side of the helix, and another in an opposite direction in the farther side. The resulting effect is therefore only the difference of the two; and in the position as shown in the figure, this difference must be very small, since the opposite sides of the helix are approximately at the same distance from *c*. But the difference of action on the two sides constantly increases as the helix is brought near the side of the ring, and becomes a maximum when the two are in the position of internal contact. A helix of larger diameter would, therefore, produce a greater effect.

48. Coil No. 1 remaining as before, helix No. 1, which is nine inches in diameter, was substituted for the small helix of the last experiment, and with this the effect at a distance was much increased. When coil No. 2 was added to coil No. 1, and the currents from two small batteries sent through these, shocks were distinctly perceptible through the tongue, when the distance of the planes of the coils and the three helices, united as one, was increased to thirty six inches.

49. The action at a distance was still further increased by coiling the long wire of the large spool into the form of a ring of

four feet in diameter, and placing parallel to this another ring, formed of the four ribands of coils No. 1, 2, 3 and 4. When a current from a single battery of thirty five feet of zinc surface was passed through the riband conductor, shocks through the tongue were felt when the rings were separated to the distance of four feet.* As the conductors were approximated, the shocks became more and more severe; and when at the distance of twelve inches, they could not be taken through the body.

50. It may be stated in this connection, that the galvanic induction of magnetism in soft iron, in reference to distance, is also surprisingly great. A cylinder of soft iron, two inches in diameter and one foot long, placed in the centre of the ring of copper riband, with the battery above mentioned, becomes strongly magnetic.

51. I may perhaps be excused for mentioning in this communication, that the induction at a distance affords the means of exhibiting some of the most astonishing experiments, in the line of *physique amusante*, to be found perhaps in the whole course of science. I will mention one which is somewhat connected with the experiments to be described in the next section, and which exhibits the action in a striking manner. This consists in causing the induction to take place through the partition wall of two rooms. For this purpose coil No. 1 is suspended against the wall in one room, while a person in the adjoining one receives the shock, by grasping the handles of a helix, and approaching it to the spot opposite to which the coil is suspended. The effect is as if by magic, without a visible cause. It is best produced through a door, or thin wooden partition.

52. The action at a distance affords a simple method of graduating the intensity of the shock in the case of its application to medical purposes. The helix may be suspended by a string passing over a pulley, and then gradually lowered down towards the plane of the coil, until the shocks are of the required intensity. At the request of a medical friend, I have lately administered the induced current precisely in this way, in a case of paralysis of a part of the nerves of the face.

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* Since writing the above, this distance has been much increased by using a compound battery of eight elements, each of the above size; with this, shocks through the tongue have been obtained, when the conductors were separated to the remarkable distance of six feet eight inches.

53. I may also mention that the energetic action of the spiral conductors enables us to imitate, in a very striking manner, the inductive operation of the magneto-electrical machine, by means of an uninterrupted galvanic current. For this purpose, it is only necessary to arrange two coils to represent the two poles of a horse-shoe magnet, and to cause two helices to revolve past them in a parallel plane. While a constant current is passing through each coil, in opposite directions, the effect of the rotation of the helices is precisely the same as that of the revolving armature in the machine.

54. A remarkable fact should here be noted in reference to helix No. 4, which is connected with a subsequent part of the investigation. This helix is formed of copper wire, the spires of which are insulated by a coating of cement instead of thread, as in the case of the others. After being used in the above experiments, a small discharge from a Leyden jar was passed through it, and on applying it again to the coil, I was much surprised to find that scarcely any signs of a secondary current could be obtained.

55. The discharge had destroyed the insulation in some part, but this was not sufficient to prevent the magnetizing of a bar of iron introduced into the opening at the centre. The effect appeared to be confined to the inductive action. The same accident had before happened to another coil of nearly the same kind. It was therefore noted as one of some importance. An explanation was afterwards found in a peculiar accident of the secondary current.*

SECTION IV.

On the Effects produced by interposing different Substances between the Conductors.

56. Sir H. Davy found, in magnetizing needles by an electrical discharge, that the effect took place through interposed plates of all substances, conductors and non-conductors.† The experiment which I have given in paragraph 51 would appear to indicate that the inductive action which produces the secondary current might also follow the same law.

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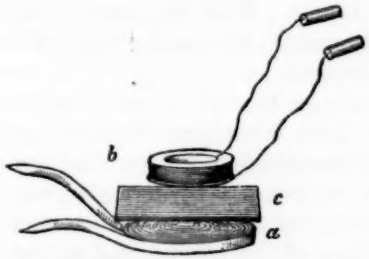
* See paragraph 75. † Philosophical Transactions, 1821.

57. To test this, the compound helix was placed about five inches above coil No. 1, Fig. 5, and a plate of sheet iron, about $\frac{1}{16}$th of an inch thick, interposed. With this arrangement no shocks could be obtained; although, when the plate was withdrawn, they were very intense.

Fig. 5.



a coil No. 1, *b* helix No. 1, and *c* an interposed plate of metal.

58. It was at first thought that this effect might be peculiar to the iron, on account of its temporary magnetism; but this idea was shown to be erroneous by substituting a plate of zinc of about the same size and thickness. With this the screening influence was exhibited as before.

59. After this various other substances were interposed in succession, namely, copper, lead, mercury, acid, water, wood, glass, &c.; and it was found that all the perfect conductors, such as the metals, produced the screening influence; but non-conductors, as glass, wood, &c., appeared to have no effect whatever.

60. When the helix was separated from the coil by a distance only equal to the thickness of the plate, a slight sensation could be perceived even when the zinc of $\frac{1}{16}$th of an inch in thickness was interposed. This effect was increased by increasing the quantity of the battery current. If the thickness of the plate was diminished, the induction through it became more intense. Thus a sheet of tinfoil interposed produced no perceptible influence; also four sheets of the same were attended with the same result. A certain thickness of metal is therefore required to produce the screening effect, and this thickness depends on the quantity of the current from the battery.

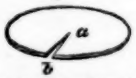
61. The idea occurred to me that the screening might, in some way, be connected with an instantaneous current in the plate, similar to that in the induction by magnetic rotation, discovered

by M. Arago. The ingenious variation of this principle by Messrs. Babbage and Herschel, furnished me with a simple method of determining this point.

62. A circular plate of lead was interposed, which caused the induction in the helix almost entirely to disappear. A slip of the metal was then cut out in the direction of a radius of the circle, as is shown in Fig. 6. With the plate in this condition, no screening was produced; the shocks were as intense as if the metal were not present.

63. This experiment however is not entirely satisfactory, since the action might have taken place through the opening of the lead; to obviate this objection, another plate was cut in the same manner, and the two interposed with a glass plate between them, and so arranged that the opening in the one might be covered by the continuous part of the other. Still shocks were obtained with undiminished intensity.

Fig. 6.



a a lead plate, of which the sector *b* is cut out.

Fig. 7.

a a lead plate, *b* the magnetizing spiral.

64. But the existence of a current in the interposed conductor was rendered certain by attaching the magnetizing spiral by means of two wires to the edge of the opening in the circular plate, as is shown in Fig. 7. By this arrangement the latent current was drawn out, and its direction obtained by the polarity of a needle placed in the spiral at *b*.

65. This current was a secondary one, and its direction, in conformity with the discovery of Dr. Faraday, was found to be the same as that of the primary current.

66. That the screening influence is in some way produced by the neutralizing action of the current thus obtained, will be clear, from the following experiment. The plate of zinc before mentioned, which is nearly twice the diameter of the helix, instead of being placed between the conductors, was put on the top of the helix, and in this position, although the neutralization was not as perfect as before, yet a great reduction was observed in the intensity of the shock.

67. But here a very interesting and puzzling question occurs. How does it happen that two currents, both in the same direc-

tion, can neutralize each other? I was at first disposed to consider the phenomenon as a case of real electrical interference, in which the impulses succeed each other by some regular interval. But if this were true, the effect should depend on the length and other conditions of the current in the interposed conductor. In order to investigate this, several modifications of the experiments were instituted.

68. First a flat coil (No. 3) was interposed instead of the plates. When the two ends of this were separated, the shocks were received as if the coil were not present; but when the ends were joined, so as to form a perfect metallic circuit, no shocks could be obtained. The neutralization with the coil in this experiment was even more perfect than with the plate.

69. Again, coil No. 2, in the form of a ring, was placed not between the conductors, but around the helix. With this disposition of the apparatus, and the ends of the coil joined, the shocks were scarcely perceptible, but when the ends were separated, the presence of the coil has no effect.

70. Also when helices No. 1 and 2 were together submitted to the influence of coil No. 1, the ends of the one being joined, the other gave no shock.

71. The experiments were further varied by placing helix No. 2 within a hollow cylinder of sheet brass, and this again within coil No. 2, in a manner similar to that shown in Fig. 12, which is intended to illustrate another experiment. In this arrangement the neutralizing action was exhibited, as in the case of the plate.

72. A hollow cylinder of iron was next substituted for the one of brass, and with this also no shocks could be obtained.

73. From these experiments it is evident that the neutralization takes place with currents in the interposed or adjoining conductors of all lengths and intensities, and therefore cannot, as it appears to me, be referred to the interference of two systems of vibrations.

74. This part of the investigation was, for a time, given up almost in despair, and it was not until new light had been obtained from another part of the inquiry, that any further advances could be made towards a solution of the mystery.

75. Before proceeding to the next Section, I may here state, that the phenomenon mentioned, paragraph 54, in reference to helix No. 4, is connected with the neutralizing action. The

electrical discharge having destroyed the insulation at some point, a part of the spires would thus form a shut circuit, and the induction in this would counteract the action in the other part of the helix; or, in other words, the helix was in the same condition as the two helices mentioned in paragraph 70, when the ends of the wire of one were joined.

76. Also the same principle appears to have an important bearing on the improvement of the magneto-electrical machine: since the plates of metal which sometimes form the ends of the spool containing the wire, must necessarily diminish the action, and also from the experiment of paragraph 72, the armature itself may circulate a closed current which will interfere with the intensity of the induction in the surrounding wire. I am inclined to believe that the increased effect observed by Sturgeon and Calland, when a bundle of wire is substituted for a solid piece of iron, is at least in part due to the interruption of these currents. I hope to resume this part of the subject, in connection with several other points, in another communication to the Society.

77. The results given in this Section may, at first sight, be thought at variance with the statements of Sir H. Davy, that needles could be magnetized by an electrical discharge with conductors interposed. But from his method of performing the experiment, it is evident that the plate of metal was placed between a straight conductor and the needle. The arrangement was therefore similar to the interrupted circuit in the experiment with the cut plate (62,) which produces no screening effect. Had the plate been curved into the form of a hollow cylinder, with the two ends of the metal in contact, and the needle placed within this, the effect would have been otherwise.

SECTION V.

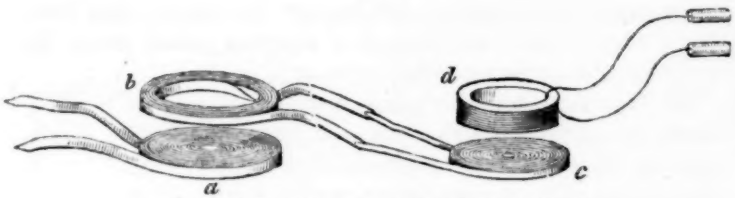
On the Production and Properties of induced Currents of the Third, Fourth and Fifth order.

78. The fact of the perfect neutralization of the primary current by a secondary, in the interposed conductor, led me to conclude that if the latter could be drawn out, or separated from the influence of the former, it would itself be capable of producing a new induced current in a third conductor.

79. The arrangement exhibited in Fig. 8 furnishes a ready means of testing this. The primary current, as usual, is passed through

coil No. 1, while coil No 2 is placed over this to receive the induction, with its ends joined to those of coil No. 3. By this disposition the secondary current passes through No. 3; and since

Fig. 8.



a coil No. 1, *b* coil No. 2, *c* coil No. 3, *d* helix No. 1.

this is at a distance, and without the influence of the primary, its separate induction will be rendered manifest by the effects on helix No. 1. When the handles *a*, *b* are grasped, a powerful shock is received, proving the induction of a tertiary current.

80. By a similar but more extended arrangement, as shown in Fig. 9, shocks were received from currents of a fourth and fifth order; and with a more powerful primary current, and additional coils, a still greater number of successive inductions might be obtained.

81. The induction of currents of different orders, of sufficient intensity to give shocks, could scarcely have been anticipated from our previous knowledge of the subject. The secondary current consists, as it were, of a single wave of the natural electricity of the wire, disturbed but for an instant by the induction of the primary; yet this has the power of inducing another current, but little inferior in energy to itself, and thus produces effects apparently much greater in proportion to the quantity of electricity in motion than the primary current.

82. Some difference may be conceived to exist in the action of the induced currents, and that from the battery, since they are apparently different in nature; the one consisting, as we may suppose, of a single impulse, and the other of a succession of such impulses, or a continuous action. It was therefore important to investigate the properties of the currents of different orders, and to compare the results with those before obtained.

83. First, in reference to the intensity, it was found that with the small battery a shock could be given from the current of the

third order to twenty-five persons, joining hands; also shocks perceptible in the arms were obtained from a current of the fifth order.

84. The action at a distance was also much greater than could have been anticipated. In one experiment shocks from the tertiary current were distinctly felt through the tongue, when helix No. 1, Fig. 8, was at the distance of eighteen inches above the coil transmitting the secondary current.

85. The same screening effects were produced by the interposition of plates of metal between the conductors of the different orders, as those which have been described in reference to the primary and secondary currents.

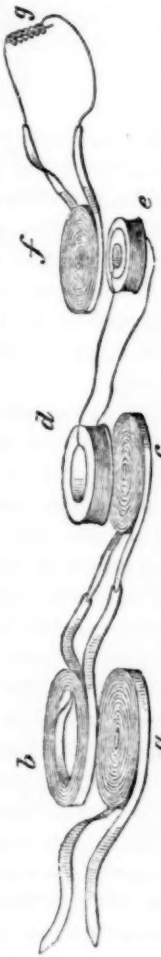
86. Also when the long helix is placed over a secondary current generated in a short coil, and which is therefore, as we have before shown, one of quantity, a tertiary current of intensity is produced.

87. Again, when the intensity current of the last experiment is passed through a second helix, and another coil is placed over this, a quantity current is again produced. Therefore, in the case of these currents, as in that of the primary, a *quantity current can be induced from one of intensity, and the converse.* By the arrangement of the apparatus as shown in Fig. 9, these different results are exhibited at once. The induction from coil No. 3 to helix No. 1 produces an intensity current, and from helix No. 2 to coil No. 4, a quantity current.

88. If the ends of coil No. 2, as in the arrangement of Fig. 8, be united to helix No. 1 instead of coil No. 3, no shocks can be obtained; the quantity current of coil No. 2, appears not to be of sufficient intensity to pass through the wire of the long helix.

89. Also, no shocks can be obtained from the handles attached to helix No. 2, in the

Fig. 9.



a coil No. 1, *b* coil No. 2, *c* coil No. 3, *d* helix No. 1, *e* helix No. 2 and 3, *f* coil No. 4, and *g* magnetizing spiral.

arrangement exhibited in Fig. 10. In this case the quantity of electricity in the current from the helix appears to be too small to produce any effect, unless its power is multiplied by passing it through a conductor of many spires.

Fig. 10.

a coil No. 2, *b* helix No. 1, *c* coil No. 3, and *d* helix No. 2.

90. The next inquiry was in reference to the direction of these currents, and this appeared important in connection with the nature of the action. The experiments of Dr. Faraday would render it probable, that at the beginning and ending of the secondary current, its induction on an adjacent wire is in contrary directions, as is shown to be the case in the primary current. But the whole action of a secondary current is so instantaneous, that the inductive effects at the beginning and ending cannot be distinguished from each other, and we can only observe a single impulse, which, however, may be considered as the difference of two impulses in opposite directions.

91. The first experiment happened to be made with a current of the fourth order. The magnetizing spiral (11) was attached to the ends of coil No. 4, Fig. 9, and by the polarity of the needle it was found that this current was in the same direction with the secondary and primary currents.* By a too hasty generalization, I was led to conclude, from this experiment, that the currents of all orders are in the same direction as that of the battery current, and I was the more confirmed in this from the results of my first experiments on the currents of ordinary electricity. This conclusion, however, caused me much useless labor and perplexity, and was afterwards proved to be erroneous.

92. By a careful repetition of the last experiment, in reference to each current, the important fact was discovered, that *there ex-*

* It should be recollected that all the inductions which have been mentioned, were produced at the moment of breaking the circuit of the battery current. The induction at the formation of the current is too feeble to produce the effects described.

ists an alternation in the direction of the currents of the several orders, commencing with the secondary. This result was so extraordinary, that it was thought necessary to establish it by a variety of experiments. For this purpose, the direction was determined by decomposition, and also by the galvanometer, but the result was still the same; and at this stage of the inquiry I was compelled to adopt the conclusion that the directions of the several currents were as follows:

Primary current, ...	+
Secondary current, ...	+
Current of the third order, . . .	−
Current of the fourth order, . . .	+
Current of the fifth order, . . .	−

93. In the first glance at the above table, we are struck with the fact that the law of alternation is complete, except between the primary and secondary currents, and it appeared that this exception might possibly be connected with the induced current which takes place in the first coil itself, and which gives rise to the phenomena of the spiral conductor. If this should be found to be *minus*, we might consider it as existing between the primary and secondary, and the anomaly would thus disappear. Arrangements were therefore made to satisfy myself fully on this point. For this purpose, the decomposition of dilute acid and the use of the galvanometer were resorted to, by placing the apparatus between the ends of a cross wire attached to the extremities of the coil, as in the arrangement described by Dr. Faraday; (ninth series;) but all the results persisted in giving a direction to this current the same as stated by Dr. Faraday, namely, that of the primary current. I was therefore obliged to abandon the supposition, that the anomaly in the change of the current is connected with the induction of the battery current on itself.

94. Whatever may be the nature or causes of these changes in the direction, they offer a ready explanation of the neutralizing action of the plate interposed between two conductors, since a secondary current is induced in the plate; and although the direction of this, as has been shown, is the same as that of the current from the battery, yet it tends to induce a current in the adjacent conducting matter of a contrary direction.* The same ex-

* See paragraph 130, Fig. 15.

planation is also applicable to all the other cases of neutralization, even to those which take place between the conductors of the several orders of currents.

95. The same principle explains some effects noted in reference to the induction of a current on itself. If a flat coil be connected with the battery, of course sparks will be produced by the induction, at each rupture of the circuit. But if in this condition another flat coil, with its ends joined, be placed on the first coil, the intensity of the shock is much diminished, and when the several spires of the two coils are mutually interposed by winding the two ribands together into one coil, the sparks entirely disappear in the coil transmitting the battery current, when the ends of the other are joined. To understand this, it is only necessary to mention that the induced current in the first coil is a true secondary current, and it is therefore neutralized by the action of the secondary in the adjoining conductor; since this tends to produce a current in the opposite direction.

96. It would also appear from the perfect neutralization which ensues in the arrangement of the last paragraph, that the induced current in the adjoining conductor is more powerful than that of the first conductor; and we can easily see how this may be. The two ends of the second coil are joined, and it thus forms a perfect metallic circuit; while the circuit of the other coil may be considered as partially interrupted, since to render the spark visible the electricity must be projected, as it were, through a small distance of air.

97. We would also infer that two contiguous secondary currents, produced by the same induction, would partially counteract each other. Moving in the same direction, they would each tend to induce a current in the other of an opposite direction. This is illustrated by the following experiment: helices No. 1 and 2 were placed together, but not united, above coil No. 1, so that they each might receive the induction; the larger was then gradually removed to a greater distance from the coil, until the intensity of the shock from each was about the same. When the ends of the two were united, so that the shock would pass through the body from the two together, the effect was apparently less than with one helix alone. The result, however, was not as satisfactory as in the case of the other experiments; a slight difference in the intensity of two shocks could not be appreciated with perfect certainty.

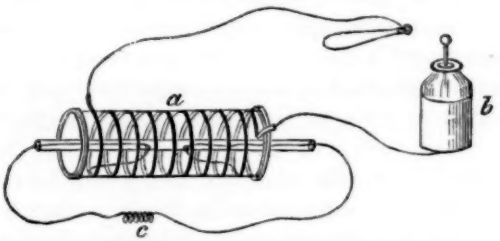
SECTION VI.

The production of Induced Currents of the Different Orders from Ordinary Electricity.

98. Dr. Faraday, in the ninth series of his researches, remarks, that "the effect produced at the commencement and the end of a current (which are separated by an interval of time when that current is supplied from a voltaic apparatus) must occur at the same moment when a common electrical discharge is passed through a long wire. Whether if it happen accurately at the same moment, they would entirely neutralize each other, or whether they would not still give some definite peculiarity to the discharge, is a matter remaining to be examined."

99. The discovery of the fact that the secondary current, which exists but for a moment, could induce another current of considerable energy, gave some indication that similar effects might be produced by a discharge of ordinary electricity, provided a sufficiently perfect insulation could be obtained.

Fig. 11.



a glass cylinder, *b* Leyden jar, *c* magnetizing spiral.

100. To test this, a hollow glass cylinder, Fig. 11, of about six inches in diameter, was prepared with a narrow riband of tin-foil, about thirty feet long, pasted spirally around the outside, and a similar riband of the same length, pasted on the inside; so that the corresponding spires of the two were directly opposite each other. The ends of the inner spiral passed out of the cylinder through a glass tube, to prevent all direct communication between the two. When the ends of the inner riband were joined by the magnetizing spiral (11,) containing a needle, and a discharge from a half gallon jar sent through the outer riband, the needle was

strongly magnetized in such a manner as to indicate *an induced current through the inner riband in the same direction as that of the current of the jar.* This experiment was repeated many times, and always with the same result.

101. When the ends of one of the ribands were placed very nearly in contact, a small spark was perceived at the opening, the moment the discharge took place through the other riband.

102. When the ends of the same riband were separated to a considerable distance, a larger spark than the last could be drawn from each end by presenting a ball, or the knuckle.

103. Also if the ends of the outer riband were united, so as to form a perfect metallic circuit, a spark could be drawn from any point of the same, when a discharge was sent through the inner riband.

104. The sparks in the two last experiments are evidently due to the action known in ordinary electricity by the name of the lateral discharge. To render this clear, it is perhaps necessary to recall the well known fact, that when the knob of a jar is electrified positively, and the outer coating in connection with the earth, then the jar contains a small excess of positive electricity beyond what is necessary to neutralize perfectly the negative surface. If the knob be put in communication with the earth, the extra quantity, or the free electricity, as it is sometimes called, will be on the negative side. When the discharge took place in the above experiments, the inner riband became for an instant charged with this free electricity, and consequently threw off from the outer riband, by ordinary induction, the sparks described. It therefore became a question of importance to determine, whether the induced current described in paragraph 100 was not also a result of the lateral discharge, instead of being a true case of a secondary current analogous to those produced from galvanism. For this purpose the jar was charged, first with the outer coating in connection with the earth, and again with the knob in connection with the same, so that the extra quantity might be in the one case *plus* and in the other *minus;* but the direction of the induced current was not affected by these changes; it was always the same, namely, from the positive to the negative side of the jar.

105. When, however, the quantity of free electricity was increased, by connecting the knob of the jar with a globe about a

foot in diameter, the intensity of magnetism appeared to be somewhat diminished, if the extra quantity was on the negative side; and this might be expected, since the free electricity, in its escape to the earth through the riband, in this case would tend to induce a feeble current in the opposite direction to that of the jar.

106. The spark from an insulated conductor may be considered as consisting almost entirely of this free or extra electricity, and it was found that this was also capable of producing an induced current, precisely the same as that from the jar. In the experiment which gave this result, one end of the outer riband of the cylinder (100) was connected with the earth, and the other caused to receive a spark from a conductor fourteen feet long, and nearly a foot in diameter. The direction of the induced current was the same as that of the spark from the conductor.

107. From these experiments it appears evident that the discharge from the Leyden jar possesses the property of inducing a secondary current precisely the same as the galvanic apparatus, and also that this induction is only so far connected with the phenomenon of the lateral discharge as this latter partakes of the nature of an ordinary electrical current.

108. Experiments were next made in reference to the production of currents of the different orders by ordinary electricity. For this purpose a second cylinder was prepared with ribands of tinfoil, in a similar manner to the one before described. The two were then so connected that the secondary current from the first would circulate around the second. When a discharge was passed through the outer riband of the first cylinder, a tertiary current was induced in the inner riband of the second. This was rendered manifest by the magnetizing of a needle in a spiral, joining the ends of the last mentioned riband.

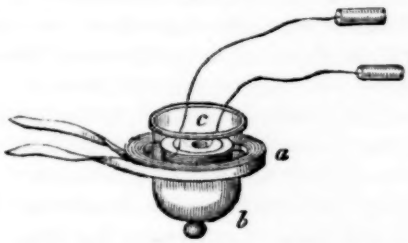
109. Also by the addition, in the same way, of a third cylinder, a current of the fourth order was developed. The same result was likewise obtained by using the arrangement of the coils and helices shown in Fig. 9. For these experiments, however, the coils were furnished with a double coating of silk, and the contiguous conductors separated by a large plate of glass.

110. Screening effects precisely the same as those exhibited in the action of galvanism were produced by interposing a plate of metal between the conductors of different orders, Figures 8 and 9. The precaution was taken to place the metal between two plates

of glass, in order to be assured that the effect was not due to a want of perfect insulation.

111. Also analogous results were found when the experiments were made with coils interposed instead of plates, as described in paragraph 68. When the ends of the interposed coils were separated, no screening was observed, but when joined, the effect was produced. The existence of the induced current, in all these experiments, was determined by the magnetism of a needle in a spiral attached to one of the coils.

Fig. 12.



a coil No. 2, *b* an inverted bell glass, *c* helices No. 2 and 3.

112. Likewise shocks were obtained from the secondary current by an arrangement shown in Fig. 12. Helices No. 2 and No. 3 united, are put within a glass jar, and coil No. 2 is placed around the same. When the handles are grasped, a shock is felt at the moment of the discharge, through the outer coil. The shocks, however, were very different in intensity with different discharges from the jar. In some cases no shock was received, when again, with a less charge, a severe one was obtained. But these irregularities find an explanation in a subsequent part of the investigation.

113. In all these experiments, the results with ordinary and galvanic electricity are similar. But at this stage of the investigation there appeared what at first was considered a remarkable difference in the action of the two. I allude to the direction of the currents of the different orders. These, in the experiments with the glass cylinders, instead of exhibiting the alternations of the galvanic currents (92,) were all in the same direction as the discharge from the jar, or, in other words, they were all *plus*.

114. To discover, if possible, the cause of this difference, a series of experiments was instituted; but the first fact developed,

instead of affording any new light, seemed to render the obscurity more profound. When the directions of the currents were taken in the arrangement of the coils, (Fig. 9,) the discrepancy vanished. *Alternations were found the same as in the case of galvanism.* This result was so extraordinary that the experiments were many times repeated, first with the glass cylinders, and then with the coils; the results, however, were always the same. The cylinders gave currents all in one direction; the coils in alternate directions.

115. After various hypotheses had been formed, and in succession disproved by experiment, the idea occurred to me that the direction of the currents might depend on the distance of the conductors, and this appeared to be the only difference existing in the arrangement of the experiments with the coils and the cylinders.* In the former the distance between the ribands was nearly one inch and a half, while in the latter it was only the thickness of the glass, or about $\frac{1}{20}$th of an inch.

116. In order to put this supposition to the test of experiment, two narrow slips of tinfoil, about twelve feet long, were stretched paralliel to each other, and separated by thin plates of mica to the distance of about $\frac{1}{50}$th of an inch. When a discharge from the half gallon jar was passed through one of these, an induced current in the same direction was obtained from the other. The ribands were then separated, by plates of glass, to the distance of $\frac{1}{20}$th of an inch; the current was still in the same direction, or *plus*. When the distance was increased to about $\frac{1}{8}$th of an inch, no induced current could be obtained; and when they were still further separated the current again appeared, but was now *found to have a different direction, or to be minus.* No other change was observed in the direction of the current with a farther increase of distance; the intensity of the induction gradually diminished as the ribands were separated. The existence and direction of the current, in this experiment, were determined by the polarity of the needle in the spiral attached to the ends of one of the ribands.

117. The question at this time arose, whether the direction of the current, as indicated by the polarity of the needle, was the

* This idea was not immediately adopted, because I had previously experimented on the direction of the secondary current from galvanism, and found no change in reference to distance.

true one, since the magnetizing spiral might possibly itself, in some cases, induce an opposite current. To satisfy myself on this point, a series of charges, of various intensity and quantity, from a single spark of the large conductor to the full charge of nine jars, were passed through the small spiral, which had been used in all the experiments; but they all gave the same polarity. The interior of this spiral is so small, that the needle is throughout in contact with the wire.

118. The fact of a change in the direction of the induced current by a change in the distance of the conductors, being thus established, a great number and variety of experiments were made to determine the other conditions on which the change depends. These were sought for in a variation of the intensity and quantity of the primary discharge, in the length and thickness of the wire, and in the form of the circuit. The results were, however, in many cases, anomalous, and are not sufficiently definite to be placed in detail before the Society. I hope to resume the investigation at another time, and will therefore at present briefly state only those general facts which appear well established.

119. With a single half gallon jar, and the conductors separated to a distance less than $\frac{1}{20}$th of an inch, the induced current is always in the same direction as the primary. But when the conductors are gradually separated, there is always found a distance at which the current begins to change its direction. This distance depends certainly on the amount of the discharge, and probably on the intensity; and also on the length and thickness of the conductors. With a battery of eight half gallon jars, and parallel wires of about ten feet long, the change in the direction did not take place at a less distance than from twelve to fifteen inches, and with a still larger battery and longer conductors, no change was found, although the induction was produced at the distance of several feet.

120. The facts given in the last paragraph relate to the inductive action of the primary current; but it appears from the results detailed in paragraphs 110 and 114, that the currents of all the other orders also change the direction of the inductive influence with a change of the distance. In these cases, however, the change always takes place at a very small distance from the conducting wire; and in this respect the result is similar to the effect of a *primary current* from the discharge of a small jar.

121. The most important experiments, in reference to distance, were made in the lecture room of my respected friend Dr. Hare of Philadelphia, with the splendid electrical apparatus described in the Fifth Volume (new series,) of the Transactions of this Society. The battery consists of thirty-two jars, each of the capacity of a gallon. A thick copper wire of about $\frac{1}{16}$th of an inch in diameter and eighty feet in length, was stretched across the lecture room, and its ends brought to the battery, so as to form a trapezium, the longer side of which was about thirty-five feet. Along this side a wire was stretched of the ordinary bell size, and the extreme ends of this joined by a spiral, similar to the arrangement shown in Fig. 13. The two wires were at first placed within the distance of about an inch, and afterwards constantly separated after each discharge of the whole battery through the thick wire. When a break was made in the second wire at *a*, no magnetism was developed in a needle in the spiral at *b*, but when the circuit was complete, the needle at each discharge indicated a current in the same direction as that of the battery. When the distance of the two wires was increased to sixteen inches, and the ends of the second wire placed in two glasses of mercury, and a finger of each hand plunged into the metal, a shock was received. The direction of the current was still the same, but the magnetism not as strong as at a less distance.

Fig. 13.

c place of the battery, *b* spiral.

122. The second wire was next arranged around the other, so as to enclose it. The magnetism by this arrangement appeared stronger than with the last; the direction of the current was still the same, and continued thus, until the two wires were at every point separated to the distance of twelve feet, except in one place where they were obliged to be crossed at the distance of seven feet, but here the wires were made to form a right angle with each other, and the effect of the approximation was therefore (46) considered as nothing. The needle at this surprising

distance was tolerably strongly magnetized, as was shown by the quantity of filings which would adhere to it. The direction of the current was still the same as that of the battery. The form of the room did not permit the two wires to be separated to a greater distance. The whole length of the circuit of the interior large wire was about eighty feet; that of the exterior one hundred and twenty. The two were not in the same plane, and a part of the outer passed through a small adjoining room.

123. The results exhibited in this experiment are such as could scarcely have been anticipated by our previous knowledge of the electrical discharge. They evince a remarkable inductive energy, which has not before been distinctly recognized, but which must perform an important part in the discharge of electricity from the clouds. Some effects which have been observed during thunder storms, appear to be due to an action of this kind.

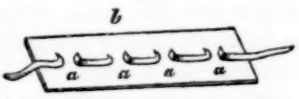
124. Since a discharge of ordinary electricity produces a secondary current in an adjoining wire, it should also produce an analogous effect in its own wire; and to this cause may be now referred the peculiar action of a long conductor. It is well known that the spark from a very long wire, although quite short, is remarkably pungent. I was so fortunate as to witness a very interesting exhibition of this action during some experiments on atmospheric electricity made by a committee of the Franklin Institute, in 1836. Two kites were attached, one above the other, and raised with a small iron wire in place of a string. On the occasion at which I was present, the wire was extended by the kites to the length of about one mile. The day was perfectly clear, yet the sparks from the wire had so much projectile force, (to use a convenient expression of Dr. Hare,) that fifteen persons, joining hands and standing on the ground, received the shock at once, when the first person of the series touched the wire. A Leyden jar being grasped in the hand by the outer coating, and the knob presented to the wire, a severe shock was received, as if by a perforation of the glass, but which was found to be the result of the sudden and intense induction.

125. These effects were evidently not due to the accumulated intensity at the extremities of the wire, on the principles of ordinary electrical distribution, since the knuckle required to be brought within about a quarter of an inch before the spark could be received. It was not alone the quantity, since the experi-

ments of Wilson prove that the same effect is not produced with an equal amount of electricity on the surface of a large conductor. It appears evidently therefore a case of the induction of an electrical current on itself. The wire is charged with a considerable quantity of feeble electricity, which passes off in the form of a current along its whole length, and thus the induction takes place at the end of the discharge, as in the case of a long wire transmitting a current of galvanism.

126. It is well known that the discharge from an electrical battery possesses great divellent powers; that it entirely separates, in many instances, the particles of the body through which it passes. This force acts, in part, at least, in the direction of the line of the discharge, and appears to be analogous to the repulsive action discovered by Ampere, in the consecutive parts of the same galvanic current. To illustrate this, paste on a piece of glass a narrow slip of tinfoil, cut it through at several points, and loosen the ends from the glass at the places so cut. Pass a discharge through the tinfoil from about nine half gallon jars; the ends, at each separation, will be thrown up, and sometimes bent entirely back, as if by the action of a strong repulsive force between them. This will be understood by a reference to Fig. 14; the ends are shown bent back at *a*, *a*, *a*, *a*. In the popular experiment of the pierced card, the bur on each side appears to be due to an action of the same kind.

Fig. 14.



b glass plate; *a*, *a*, *a*, *a*, openings in tinfoil.

127. It now appears probable, from the facts given in paragraphs 119 and 120, that the table in paragraph 92 is only an approximation to the truth, and that each current from galvanism, as well as from electricity, first produces an inductive action in the direction of itself, and that the inverse influence takes place at a little distance from the wire.

128. In reference to this view, the compound helix was placed on coil No. 1, to receive the induction, and its ends joined to those of the outer riband of tinfoil of the glass cylinder, while the magnetizing spiral was attached to the ends of the inner riband. A feeble tertiary current was produced by this arrangement, which in two cases gave a polarity to the needle indicating a di-

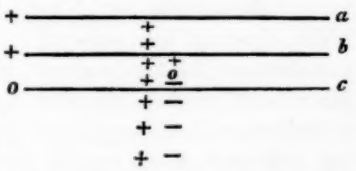
rection the same as that of the primary current. In other cases the magnetism was either imperceptible or *minus*. With an arrangement of two coils of wires around two glass cylinders, one within the other, the same effect was produced. The magnetism was less when the distance of the two sets of spires was smaller, indicating, as it would appear, an approximation to a position of neutrality. These results are rather of a negative kind, yet they appear to indicate the same change with distance in the case of the galvanic currents, as in that of the discharge of ordinary electricity. The distance however at which the change takes place, would seem to be less in the former than in the latter.

129. There is a perfect analogy between the inductive action of the primary current from the galvanic apparatus and of that from the larger electrical battery. The point of change, in each, appears to be at a great distance.

130. The neutralizing effect described in Sections IV and VI, may now be more definitely explained by saying that when a third conductor is acted on at the same time by a primary and secondary current (unless it be very near the second wire) it will fall into the region of the *plus* influence of the former, and into that of the *minus* influence of the latter; and hence no induction will be produced.

131. This will be rendered perfectly clear by Fig. 15, in which *a* represents the conductor of the primary current, *b* that of the secondary, and *c* the third conductor. The characters + + +, &c., beginning at the middle of the first conductor and extending downwards, represent the constant *plus* influence of the primary current, and those + 0 − −, &c., beginning at the second conductor, indicate the inductive influence of the secondary current as changing with the distance. The third conductor, as is shown by the figure, falls in the *plus* region of the primary current, and in the *minus* region of the secondary, and hence in it the two actions neutralize each other, and no apparent result is produced.

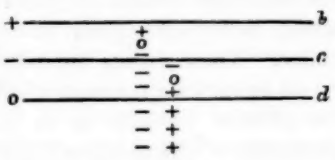
Fig. 15.



132. Fig. 16 indicates the method in which the neutralizing effect is produced in the case of the secondary and tertiary currents.

The wire conducting the secondary current is represented by *b*, that conducting the tertiary by *c*, and the other wire, to receive the induction from these, by *d*. The direction of the influence, as before, is indicated by + 0 − − &c., and the third wire is again seen to be in the *plus* region of the one current, and in the *minus* of the other. If, however, *d* is placed sufficiently near *c*, then neutralization will not take place, but the two currents will conspire to produce in it an induction in the same direction. A similar effect would also be produced were the wire *c*, in Fig. 15, placed sufficiently near the conductor *b*.

Fig. 16.



133. Currents of the several orders were likewise produced from the excitation of the magneto-electrical machine. The same neutralizing effects were observed between these as in the case of the currents from the galvanic battery, and hence we may infer, that also the same alternations take place in the direction of the several currents.

134. In conclusion, I may perhaps be allowed to state, that the facts here presented have been deduced from a laborious series of experiments, and are considered as forming some addition to our knowledge of electricity, independently of any theoretical considerations. They appear to be intimately connected with various phenomena, which have been known for some years, but which have not been referred to any general law of action. Of this class are the discoveries of Savary, on the alternate magnetism of steel needles, placed at different distances from the line of a discharge of ordinary electricity,* and also the magnetic, screening influence of all metals, discovered by Dr. Snow Harris of Plymouth.† A comparative study of the phenomena observed by these distinguished *savants*, and those given in this paper, would probably lead to some new and important developments. Indeed every part of the subject of electro-dynamic induction appears to open a field for discovery, which experimental industry cannot fail to cultivate with immediate success.

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* Annales de Chimie et de Physique, 1827.

† Philosophical Transactions, 1831.

Note.—On the evening of the meeting at which my investigations were presented to the Society, my friend, Dr. Bache of the Girard College, gave an account of the investigations of Professor Ettingshausen of Vienna, in reference to the improvement of the magneto-electric machine, some of the results of which he had witnessed at the University of Vienna about a year since. No published account of these experiments has yet reached this country, but it appears that Professor Ettingshausen had been led to suspect the development of a current in the metal of the keeper of the magneto-electric machine, which diminished the effect of the current in the coil about the keeper, and hence to separate the coil from the keeper by a ring of wood of some thickness, and afterwards, to prevent entirely the circulation of currents in the keeper, by dividing it into segments, and separating them by a non-conducting material. I am not aware of the result of this last device, nor whether the mechanical difficulties in its execution were fully overcome. It gives me pleasure to learn that the improvements, which I have merely suggested as deductions from the principles of the interference of induced currents (76,) should be in accordance with the experimental conclusions of the above named philosopher.*

ART. II.—*Analysis of a Chromic Iron Ore, first observed by* R. C. TAYLOR, Esq., *at Mahobal, near Gibara, Island of Cuba;* by JAMES C. BOOTH and M. CAREY LEA.

1. *Description.*—This mineral has a black color, and shining metallic lustre, closely resembling Franklinite from New Jersey. It is moderately brittle, exhibiting a chocolate brown streak, when reduced to the finest powder. The mass consists of coarsely crystalline particles, aggregated together, with intervening talcose matter, of a lighter color and softer texture than the chromic iron. This crystalline structure is so evident, that triangular faces of the octahedron are observable in a majority of the specimens.

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* The reader is referred to a subsequent paper by Prof. Henry, (containing important additions to the facts stated in this article,) of which an account is given in the present Number, among the *Proceedings of Am. Phil. Soc.*, under date of October 18, 1839.—*Eds.*

2. Before the blowpipe, it dissolves in a bead of borax or microcosmic salt, exhibiting the characteristic reaction of oxide of chrome.

3. *Analysis.*—To obtain a proper specimen of the mineral for analysis, it was coarsely broken up and separated from the gangue, as far as practicable. It was then finely pulverized, and one gramme of it ignited with carbonate of soda and caustic potassa, in order to convert the oxide of chrome into chromate of potassa.

4. The fused mass was digested with water and thrown upon a filter, which separated the oxide of iron and that portion of the mineral which had not been decomposed, from the other constituent which passed through in solution. The filter was then treated with hydrochloric acid, which dissolved the iron, leaving the undecomposed ore on the filter. This was found to amount to .353.

5. The solution of chloride of iron which passed through, was then digested with nitric acid, and the peroxide precipitated by ammonia. This amounted to .172. In a previous experiment, it was found to contain neither alumina nor magnesia.

6. The solution obtained by the first filtration (4), was next neutralized by nitric acid, enough being added to precipitate and redissolve the alumina. The latter was then precipitated by bicarbonate of soda and its weight found to be .1414.

7. The remaining solution was now evaporated to dryness with carbonate of soda, and treated with water. The magnesia thus rendered insoluble, was separated and amounted to .090.

8. In the solution from (7), there still remained the oxide of chrome, which was estimated by concentrating the liquid by evaporation and adding to it while boiling, hydrochloric acid and alcohol. The chromic acid, thus converted into oxide of chrome, was precipitated by ammonia and separated on a filter. The solution passing through, still contained a small portion of oxide of chrome and was therefore evaporated to dryness and digested with water. The oxide of chrome thus rendered insoluble, was added to that before obtained, and the weight of the whole amounted to .244.

9. *Conclusions.*—The streak of the mineral being chocolate brown, it is difficult to say whether this color arises from the protoxide of iron or the brown oxide of chrome, a problem of exceed-

ingly difficult solution by chemical analysis. Supposing the iron, however, to be in the state of protoxide, the .172 will be reduced to .1544 of protoxide. Now if ignition with carbonate of soda and caustic potassa, left a portion of the mineral undecomposed, it may without great error be assumed that the iron in this portion has not been peroxidized by that operation, and that therefore .353 is the correct weight of the undecomposed portion of the mineral. By adding the several weights obtained, we have,

Oxide of chrome, - - - - -	.2440
Protoxide of iron, - - - - -	.1544
Alumina, - - - - - - -	.1414
Magnesia, - - - - - - -	.0900
Undecomposed ore, - - - - -	.3530
	.9828

This shows a loss of 1.72 per cent., which may be ascribed in part to errors in analysis, and partly, without impropriety, to a partial peroxidation either of the iron or chrome.

By omitting the undecomposed matter, and calculating the percentage of each ingredient, we find the mineral to consist of

Oxide of chrome, - - - - -	38.742
Protoxide of iron, - - - - -	24.516
Alumina, - - - - - - -	22.452
Magnesia, - - - - - - -	14.290
	100.000

This result indicates that a portion of the talcose matter was included in the specimen, notwithstanding the care exercised in its separation. Viewing the alumina, with a little silica included in it and the magnesia, as belonging to the talc, we find the formula for the oxides of chrome and iron, to be 2 : 3, or $3(FeO)+2(Cr^2O^3)$. The formula generally received for the pure mineral is $2Cr+Fe$, and leads to the supposition, that in the present case, a portion of the iron exists as peroxide, a view which is strengthened by the brown streak of the mineral.

Philadelphia, Dec. 5, 1839.

ART. III.—*Remarks upon some of the probable effects of a Resisting Medium;* by THOMAS H. PERRY, Prof. Maths. U. S. N.

IT is a somewhat common opinion, that the resisting medium believed to occupy the planetary spaces, must eventually destroy the motions of the solar system. This conclusion does not seem to me to be justified by the state of the facts at present known: and, although it may not be easy to demonstrate the absolute impossibility of such an effect, the admirable provisions for the continuance of the present arrangement of the heavenly bodies, which science has already elicited, ought to be considered, at least until contrary probabilities are shown to exist, presumptive indications of its future permanence.

The final effects of a resisting medium must depend upon its extent and mode of distribution. The facts from which its existence is deduced, do not apprise us whether it is, or is not, limited to a comparatively small distance from the sun; nor whether it is diffused *continuously* from this luminary to the remotest limits of his system, or is disposed about him in concentric zones, separated by intermediate spaces, incapable of impeding ponderable bodies. It is not a legitimate inference that the medium by which comets are retarded is essential to the transmission of light, and therefore the visibility of the remotest stars, which would in that case be a relevant fact, has no necessary connection with the subject.

Were it proved that the ether is in its extent as unlimited as space, and that its elasticity is no where counterbalanced by any kind of attraction, it would indeed follow that its effects, however inappreciable and indefinitely slight in any finite period, must become sensible, when augmented by the increments of time in the same degree indefinitely great; and that the planets, as has been often asserted, must, in the lapse of a sufficient series of ages, fall to the sun.

But while we have, in known facts, no evidence that the ether is thus universally diffused, we are led by analogy and the favorite theories of the age, to presume the contrary. If, as every circumstance that has any bearing upon the subject conspires to evince, all the ponderous globes in the universe, once pervaded space as attenuated nebulæ, surely it must require great elasticity and expansion of the ethereal matter to fill the vacuum formed by

their condensation; unless, indeed, it be assumed that it has ever penetrated alike the interstices between the particles of solid, fluid and aeriform bodies; an assumption which might involve us in unauthorized conclusions.

If this medium be possessed of gravity, as we might consistently presume, especially since it must otherwise tend to recede from the sun and planets into infinite space, leaving them and their satellites to revolve in vacuo; it may be considered as a circumsolar atmosphere, subject to the usual laws of atmospheric density and limitation, modified by its vast extent, its extreme tenuity, by any relevant peculiarities it may possess, and by the present and past condition and changes of the system.

In objecting then to the prevalent opinion stated at the commencement of these remarks, it seems that we are authorized, by the state of such known facts, analogies and principles as relate to the subject, and by the condition and position of the argument, to presume that the resisting medium is finite in extent; and that, being so constituted as to obey the laws of physical mechanics, its particles, if once in a state of revolution about the sun, would have a tendency to continue their motions, upon the same principles according to which the planets describe their respective orbits. And therefore, whatever may have been its primary condition, it must have, in the existing state of things, motions consentaneous with those of the sun and planets, which have been so long revolving in it, in the same angular direction, and in nearly the same plane; since it could require a small fraction only of their momenta, to communicate rotation to a medium so rare as to impede very little bodies of immense magnitude, yet incapable of disturbing sensibly the satellites of Jupiter, when in close proximity.

Again, as the planets nearest the sun revolve most rapidly, the *angular velocity of the ether must also vary with the distance.* Supposing it to have ever been continuous, the exterior portions would be accelerated by the friction of those near the centre, until the centrifugal force should exceed the centripetal, when the former would begin to recede, thereby producing a successive separation into zones, upon principles somewhat analogous to those according to which, a similar arrangement of the primeval belts of planetary vapors is alleged to have taken place. Whatever may have been its original condition, it would be difficult to con-

ceive how any other mode of distribution than what is here supposed eventually to obtain, could be *permanent.*

Those who admit the nebular theory, would hardly contend that the ether has been otherwise circumstanced since the detachment of the planetary rings. While each expanded belt or attenuated globe was describing the orbit which the planet has since described, a medium capable of resisting its motions, could not remain at rest. There is no known reason why an incongruity of angular velocity, and partial equilibrium of the centripetal and centrifugal forces, capable of separating the zones of grosser matter exceedingly rarefied, should fail to produce analogous effects upon any other fluid, governed by similar laws, and having like diversities of velocity. And should the belts of ether, having their several appropriate rates of motion, and separated by considerable intervals, probably, even before the completion of the earlier adjustments of the system, subsequently interfere with each other, or be otherwise disturbed, the same causes which would be capable of producing it, must operate to restore the arrangement.

Should it be assumed that this medium is, and must necessarily *remain continuous*, and that such a disposition of it as has been indicated, is impossible, it is conceded that the system must experience important changes. The impropriety of any such assumption has been already shown. Since then no disposition or tendency of the resisting medium inconsistent with the purposes of our argument, is at all probable, and since the planets cannot be retarded by a medium having the same periodical revolution with themselves, it is conceived that we are justified in concluding that we have no sufficient reason to infer that these bodies must, from any such cause, fall to the sun.

But although what has been already advanced is deemed sufficient to evince that the orbits of the principal planets are not likely to experience any essential alteration from the causes under discussion, the possible effects upon the rotation of the primaries upon their axes, and upon all the motions of their secondaries, remain to be noticed. Such motions, whenever they take place in a zone of ethereal fluid, must evidently be resisted until the contiguous portions acquire an equal rotation. This could not happen, until they should cease to be retarded by other and exterior portions; but that it must sooner or later take place is evident from the following considerations.

1st. The circumferences of circles being as their radii, and gravity inversely as the square of the distance; the centrifugal force of portions remote from the primary, at length exceeding the force of attraction, must cause them to recede; and this process must continue as long as the momenta of the planet and its satellite continue to be transmitted to the circumference of its tenuous atmosphere.

2nd. The rotation of any mass having motions similar to those of the planets, must, as might easily be proved, have a tendency to remove a resisting medium from its path, and therefore if ever the ether were so disposed as to interfere with the motions of the planets and their satellites, it must, unless retained by causes of whose existence we are not apprised, recede from the vicinity of their orbits.

3rd. So much of the ether as should nevertheless be retained by the attraction of any of these bodies, would probably be disposed in concentric zones, analogous to those in the general system, and upon similar principles; after the separation of which zones, the influence of a resisting medium would cease to be felt, at least until their arrangement should be disturbed.

4th. And finally, as the magnitude of the planetary bodies was probably much greater formerly than at present, it may be presumed that most of these changes occurred before the process of condensation was completed.

The ether once distributed throughout the system as has been indicated, and with the elements of readjustment, must resist the action of a disturbing force. A cause of disturbance exists in the excentric motions of comets, which in their course must necessarily displace portions of the intersected zones. But this cause can hardly exceed the force requisite to render their present orbits consentaneous with the general motions of the system. Besides, while it acts with exceeding slowness in widely distant regions, it operates at the two intersections of each zone made in a revolution, in nearly opposite directions; and therefore comparatively feeble as the resulting forces must be, under any circumstances, it is possible that in consequence of its mode of operation, this cause may effect little else than temporary oscillations of the medium until it ceases to act.

The consideration of influences and consequences foreign to the system, has been thus far, for the most part, purposely avoided.

A little reflection however will evince that if we view the starry universe as composed of *systems of systems*, acknowledging a common centre, and suppose a resisting medium to be partially diffused throughout, the preceding reasoning would with a little modification be applicable to its mode of distribution. Even here we find no cause to apprehend the dissolution of creation, or to infer that physical worlds will cease to exist, as theatres for the operation of the infinite love and infinite wisdom of the Divine Creator.

I am aware that there are those whose religious feelings are enlisted to prove, upon philosophical grounds, the certainty of the final destruction of at least this terrestrial globe; and who may therefore distrust the tenor of the foregoing remarks. With the hazards to which our earth may be exposed from other sources, I have at this time nothing to do. But with all due deference to those who may differ from me in opinion, if such there are, although I revere the sacred scriptures as the manifestation of divinity to man, I do not regard them as designed to instruct us in physical philosophy. Prophecy has not always been understood until the time of its fulfilment; and while some contend, as the admirers of Swedenborg, that the word of God contains throughout a figurative or spiritual sense, the prophecies are confessedly full of metaphor. In those relating to the final consummation of all things, circumstances are stated which must be considered figurative. It is not improbable that others are misunderstood, and it is believed to be alike dangerous to science and to religion, to be unduly biased in our investigations of philosophical questions, by uncertain interpretations of the sacred volume.

ART. IV.—*Description and Analysis of a Meteoric mass, found in Tennessee, composed of Metallic Iron, Graphite, Hydroxide of Iron and Pyrites;* by G. TROOST, M. D., Prof. of Chemistry, Mineralogy and Geology in the University of Nashville, Tenn.

DURING my excursions through East Tennessee, I had seen small fragments of native iron, and had heard of large masses of it, which were believed to be silver. It being considered a precious metal, all that was known about it, and the place where it was found, were kept a profound secret. Some less prejudiced inhabitant at last became acquainted with the nature of the metal,

and its real value was made known. To the politeness of Col. Micajah C. Rodgers, of Serierille, I am indebted for a considerable quantity of it; and the Hon. Judge Jacob Peck of Jefferson County, has also presented me with some small fragments. I am thus enabled to lay a description of this singular substance before the scientific public.

Having ascertained, as appears from the analysis below given, that this iron contains nickel, the mass must be considered of meteoric origin; but it differs from most of the masses of meteoric iron hitherto described. The original weight of it is said to have been about 2000 pounds. The portions that I have seen, (as well as those which are in my possession,) present a singular heterogeneous mixture of metallic iron, carburet of iron or graphite, sulphuret of iron, (pyrites,) and hydroxide of iron, the latter, brown and yellow; in some parts all four ingredients form a kind of homogeneous mixture.

The most abundant constituent, however, is the nickeliferous iron, and it composes about $\frac{9}{10}\frac{5}{0}$ths of the whole mass. It has partly a crystalline structure, and is in part, composed of grains or globules of various sizes and forms, merely agglutinated together, or sometimes separated by a thin flexible highly polished pellicle of graphite. The crystalline part is composed of laminæ of various thickness, in the form of equilateral triangles, which are separated from each other by very thin flexible pellicles, as mentioned above respecting the grains.

I expected to find these triangular laminæ placed in such position as to form octahedrons, or showing a cleavage parallel to the sides of a regular octahedron; but this is not the case, as the cleavage gives a regular tetrahedron. I have one of these forms, which is about an inch from base to apex.

The metallic iron is also dispersed in small irregular-shaped masses through a hard, compact, brown hydrated oxide of iron. Throughout this the iron is also dispersed in invisible grains, to be detected only by the magnet, which attracts them when the substance has been reduced to powder.

This iron is malleable. I have in my possession a horse-shoe nail, which was made of it without having undergone a previous preparation, but it is harder and whiter than common wrought iron. This hardness and color may be owing to a small quantity of carbon which it contains, or perhaps to the nickel; in its natural state, however, the color of the iron differs much in different

parts. In some it is black, and has no metallic lustre; in others, it has a brilliant metallic lustre, and is then always much whiter than steel or common iron. It is then but little susceptible of being tarnished when exposed to the action of the air; the black part being merely tarnished, may be rendered white by a file; in some places it is covered with a kind of black varnish.

The substance which constitutes the greatest part of the remainder of the mass, is graphite. This substance is not easily distinguished from the common graphite or plumbago, except that it is a little harder than the common granular and compact varieties, and is also rather blacker, and makes a finer, blacker, and more distinct line upon paper than common plumbago. When rubbed with a hard body it assumes a bright metallic lustre. It is not pure graphite, but rather a mixture of graphite and metallic iron. The iron can be partly removed by a magnet when the graphite is reduced to powder, but a considerable portion remains mixed with the graphite, which, when acted upon with hydrochloric acid, is dissolved with a brisk effervescence of hydrogen gas.

The sulphuret of iron, or pyrites, occupies the smallest portion of the mass. This pyrites is not attracted by the magnet, nor does it seem to act upon the magnetic needle. It can easily be cut with a knife, and is consequently softer than common pyrites. It does not give sparks when struck with steel, another property which distinguishes it from common pyrites. It is easily soluble in diluted hydrochloric acid, with a brisk evolution of sulphuretted hydrogen gas, leaving a mixed powder of white and black in the fluid. It has a more or less sub-lamellar structure, in which no regularity can be perceived, and a color between bronze yellow and copper red, often tarnished.

The hydroxide of iron, which forms part of this mass, is a heterogeneous mixture of the varieties of the ore generally known under the names of brown iron ore and yellow ochre, and resembles this terrestrial mineral. Its color is generally brownish black, passing into liver brown. The external surface of the mass is covered here and there with the yellow earthy variety (yellow ochre); how far this covering extended, I am not able to say, as the mass was too roughly handled before any part of it came into my possession. Its fracture resembles that of the common compact brown iron ore. The blackish brown variety is so very hard, that the best file is immediately dulled upon it, and leaves

particles of the steel on the surface of the ore. Nevertheless, the whole is not of uniform hardness; a part, particularly the liver brown, being scratched by the file.

Some small cavities in it are lined with lamellar crystals, resembling those of white pyrites.

This hydroxide, which serves as a matrix of the metallic iron, is not, judging from my specimens, abundant in the interior of the mass, but the exterior of the mass is entirely made up of it. At some places it is about one inch thick, while at others it is no more than one quarter of an inch, showing here and there small points of the metallic iron piercing through it.

Such are the characters and appearances of this mass, of the date and circumstances of whose fall, nothing is known. It was accidentally discovered near Cosby's creek, in the southwestern part of Cocke County, East Tennessee, and as I mentioned above, was considered as silver ore. Indeed, there is yet a fragment of it in the hands of an inhabitant, who asks for it $1500—a sum, which would be some hundred dollars too much, if it were pure silver.

Chemical constituents of the different parts.

1. *Metallic Iron.*—100 grains of the metallic iron were dissolved in diluted hydrochloric acid, leaving a residue of half a grain of a black powder, similar to that obtained from the graphite. This solution being treated with nitric acid, to convert the protoxide into peroxide, was precipitated by pure ammonia. The precipitate being washed and ignited, gave 124 grains of peroxide, = 87 grains of iron. The ammoniacal solution gave 16 grains of protoxide of nickel, = 12 grains of metallic nickel, with a trace of cobalt; loss, half a grain.

Iron,	87.0
Nickel,	12.0
Carbon,	0.5
Loss,	0.5
	100.0

2. *Graphite.*—50 grains of the graphite being pulverized and freed by a magnet from intermixed iron, were acted upon with diluted hydrochloric acid. An effervescence took place, with expulsion of hydrogen gas, owing to metallic iron, which was so intimately mixed with the graphite, that it was not attracted by

the magnet. After the effervescence ceased, it was heated in order to dissolve every thing that was soluble. The insoluble part was washed and dried; it was pure carbon, and weighed 46½ grains.

The hydrochloric solution being treated with nitric acid, to convert the protoxide of iron into peroxide, and precipitated by ammonia, gave peroxide of iron equal to three grains of metallic iron. The filtered solution was treated with pure potassa, and a hardly perceptible gray flocculent precipitate was obtained, so that this iron was free from nickel.

Carbon,	46.5
Iron,	3.0
Loss,	0.5
	100.0

3. *Sulphuret of Iron.*—A small fragment of the pyrites was dissolved in diluted hydrochloric acid, under a brisk effervescence of sulphuretted hydrogen gas. Part of it was insoluble; this after being washed and dried, was exposed to heat, by which the sulphur was sublimed, leaving a black powder. The quantity used was too small to determine the proportion; it is composed of *sulphuret of iron and carbon.*

4. *Hydroxide of Iron.*—The hydroxide of iron lost about 17 per cent. by being heated, and had all the characters of a similar residue from brown ironstone or hæmatite.

This is not the only instance in which meteoric iron has been found in the State of Tennessee. A small mass of it was found in Dickson County; another, a few miles west of Canyfork in De Kalb County. The latter had a smooth glossy surface, and was of an oval shape, its longer diameter being from 10 to 12 inches.

It is said that several masses have been found about 20 miles east from the warm springs in Buncombe County, North Carolina. I went to the spot, during my last excursion in East Tennessee, but I could learn nothing with certainty concerning it, and did not see any of the metal.*

Nashville, Tenn., Nov. 8, 1839.

* One mass, at least, of meteoric iron has been found in this county, and an analysis of it was published by Prof. C. U. Shepard, in this Jour. Vol. 36, p. 81.—Eds.

ART. V.—*Notice of Tracks of Animals in Variegated Sandstone at Pölzig, between Ronneburg and Weissenfels;* by Hr. Dr. B. COTTA.*

Translated for this Journal by Rev. Prof. W. A. LARNED, of Yale College.

WHILE recently engaged in revising the preparations for the geological map of Saxony, in the country between Ronneburg and Weissenfels, I frequently met with stone slabs in the region of the variegated sandstone, which were covered on one side with the same sort of reticular padding as the track-sandstone of Hildburghausen. These net-formed pads could have originated in no other way, as every thing about them shows, than by the filling up of clefts occasioned by the drying of thin layers of clay. But if thin beds of clay formed between sandstone strata, had time and opportunity for drying before the deposition of a new layer of sand, then manifestly there existed some of the essential pre-requisites for the preservation of ancient foot-prints; it would only be necessary that there should be animals at that period to roam at will over the soft clay, before the water covered it anew with sand. Under these impressions, I began to search for foot-tracks on my way to Pölzig, where, as I was informed, the slabs were abundant. Before reaching the quarries at Pölzig and Klein-Pörthen, I observed at a village, in a heap of building stones, several small elevated figures, which arrested my attention on account of their similarity in form and size; their form, however, appeared so remarkable that I could hardly persuade myself they were casts of tracks, although I was in search of such. On arriving, however, at the quarry of Pölzig, I obtained full evidence that these figures actually originated from the footsteps of animals. Several large slabs were here entirely covered with them, and in one place at the first quarry, on the left slope of the valley above Pölzig, I found the track-stratum still remaining, a portion dug under and covered on the under side entirely with reliefs. Such is the history of the discovery, though it is but just to say, that had not Dr. Sickler led the way, I should never have thought of

* Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefaktenkunde, herausgegeben von Dr. K. C. v. Leonhard und Dr. H. G. Bronn, Professoren an der Universität zu Heidelberg. Erstes Heft. 1839.

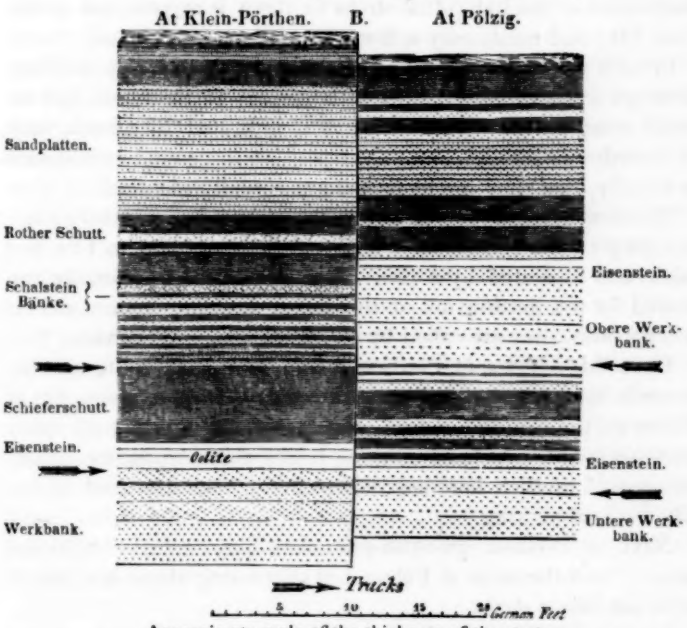
looking for foot-prints here, nor recognized these when accidentally found, as such.

A.

The form of these foot-reliefs, which resemble those of Hildburghausen in no other respect than the mode of their occurrence, is very peculiar, being two-toed, and more like horse-shoes than feet. I sought in vain for any regular arrangement or the continuous course of any one individual; all the tracks stood singly, as in the above plate A, in as much disorder as if there had been a large tumultuous assemblage of animals there. For this reason, the forms of individual casts are often not expressed entire, and all are not alike, some being rounded behind, (2, 3, 7 and 8,) and others more angular, (1, 4 and 5;) sometimes we observe on the hind part a little irregular prominence, (5 and 6.) These variations may have arisen, in part, though hardly all of them, from the inequality of the soft ground, from the impression and direction of the foot, &c. The irregular position speaks rather for two-footed than four-footed animals. Some slabs are covered with little round bosses of the same size with the foot-casts; these, however, occur only on the under surface of the layers resting on the clay. Could the clay, in a certain state of softness, have hardened on the feet so as to make their prints obscure?

The net-formed pads had first led me, as already observed, to search for tracks; I was, therefore, quite surprised to find them so rarely in connection with the foot-tracks, although occurring very abundantly in the same quarry. The clayey underlayer of the track-strata happens to be so thin here ordinarily, ($\frac{1}{4}$–$\frac{1}{2}$ an inch,) that it perhaps on this account did not crack in drying. I would remark farther on one striking peculiarity of the track-slabs of this place; they are generally very undulatory upon the side opposite the impressions, that is, the upper, and more even on the under. The water evidently has had more effect on the sand than on the tough clay.

New Red Sandstone formation.



Approximate scale of the thickness of the strata.

The track-reliefs occur at Pölzig and Klein-Pörthen, it is probably only in two layers, whose particular position is indicated on the plate (B) by small arrows. These layers belong in general to the middle region of the variegated sandstone formation. They are characterized throughout the whole district by gray, yellow, and even white colors; at Crossen, on the Elster, we see them

distinctly embedded upon the lower red sandstone, and in the Saal valley, between Weissenfels and Dürrenberg, they are covered by the upper red clay. We find traces of track-casts also at Crossen, at Weissenfels, and at Gross-Aga not far from Zeitz; however, only here and there, and perhaps less distinctly than at Pölzig. At the latter place, the animals seem to have congregated in herds. But however rare they appear in the other places, the wide extent of the region in circumstances favorable to their hardening, is worthy of attention.

The quarries of Pölzig and Klein-Pörthen are situated in parallel level vallies, and are separated from one another by a mountain ridge about an hundred feet high and one mile broad. The arrangement of the individual strata in them is represented on the plate, (B,) and needs only a few explanations in addition.

In both places, the sequence of the strata is tolerably uniform, although some variations exist with respect to thickness and internal composition. The track-strata, indicated by arrows, may be regarded as parallel, since their position in general corresponds so exactly, that they might be held as actually identical.

The lowest track-layer in both places occurs in a minutely granular gray-yellow sandstone, whose strata, from one to two feet thick, and separated by a thin layer of clay, are preferably employed for the getting out of the larger building-stones, and on this account, they are called by the workmen, "Werkbank."*

Upon this follows, at Pörthen, a firm, dark gray oolite, passing beneath into gray sandstone with traces of copper-green, but at Pölzig on the contrary, a firm, gray sandstone, which only rarely contains oolite. At both of these places these strata are called, on account of their hardness, "Eisenstein," and are used especially for road making.

Next, at Pörthen, greenish-gray slate clay, called "Schieferschutt," and the same at Pölzig, but alternating above and below with sandstone strata.

On this follows, at both places, the upper track-layer, on the under surface of the sandstone strata, which, at Pörthen, are thin, and frequently alternating with slate-clay, on which account they

* The local terms employed by the workmen I have not thought it necessary to translate in the text or plate. I give their literal signification Werkbank, *shop-board or work-bench;* eisenstein, *ironstone;* schieferschutt, *slate earth;* schalstein-bänke, *shale-banks;* rother schutt, *red earth;* sandplatten, *sandplates.*—*Tr.*

are called, "Schalsteinbänke;" while at Pölzig they correspond to the under "Werkbank," and are called the upper "Werkbank." This sandstone formation at Pölzig, consists of thinner strata, is firmer, and more gray, on which account it is called, in the upper region, "Eisenstein;" but I found no oolite there.

On these sandstone strata, follows at both places, slate-clay, with one or two sandstone plates intermediate. At Pörthen, however, it is colored rather red, than greenish gray, and is there called, "rother Schutt." Upon this, rest the so called, "Sandplatten," thin, yellow sandstone strata, which extend over a much larger region at Pörthen than at Pölzig.

The slate-clay and sandstone, finally, which cover these sand plates, occur only in some places in the highest parts of the quarries, and in general considerably contorted.

The engraved plate is not to be regarded as geometrically exact, for the thickness of the layers is only conjectured, and it is in the main, a representative of several contiguous quarries, rather than an accurate copy from one, which appeared to me would be exact enough for the present object.

I proceeded in a similar manner, with the copies of the foot-tracks: they are sketched, indeed, individually exact, according to their natural size, being even measured with the compasses; but their relative position is arbitrary, they being placed thicker than is usual on the slabs, as the most distinct reliefs of several individual slabs, are united in a small space. Besides, the form in these hasty outlines, may be more sharply marked out, than is really the case in nature, in order to make up for the want of a practiced hand, which alone can represent any thing distinctly, and yet true to nature. These sketches may give an idea of the thing, but a better account may be hoped for, from Professor Rossmässler, for whom I have this day ordered a wagon-load of the large slabs to Freiberg.

ART. VI.—*Observations on the Aurora Borealis of September* 3, 1839; communicated by EDWARD C. HERRICK, Rec. Sec. Conn. Acad.

ON the night of Tuesday, the 3d of September, 1839, an extraordinary display of the Aurora Borealis was seen in all parts of the United States, and was probably also visible over a large portion of the northern hemisphere above the latitude of 30°. The public attention throughout the country, was much attracted by this display, and numerous descriptions of its phenomena were published in the newspapers. I propose here to give a brief abstract of some of these accounts.

1. *New Haven.* Observations were made here by Mr. A. B. Haile, Mr. F. Bradley, and myself, and doubtless also by many others. The auroral light was first noticed about half an hour after sunset, and of course while the twilight was quite strong. At this time the sky was much obscured by thin clouds, but these gradually dispersed. As daylight faded, the Aurora grew more conspicuous, and soon presented a most splendid scene. So many good detailed descriptions of great Auroral displays have however already been published in this Journal, that it seems unnecessary to attempt in this place a very minute account of the particulars of this instance. Previous to midnight, there were three or four seasons of maximum energy, during which a large portion of the heavens was covered with a vast assemblage of streamers of various hues, in which crimson and silver-white predominated. The exhibition was, on the whole, quite equal in splendor to any which we have ever seen in this region. Several times in the course of the evening, the corona was distinctly formed, enveloped, as usual in a tumultuous, ever-shifting mass of Auroral light. The mean of numerous observations of the altitude of the centre of the corona, taken by a plumb-quadrant, gave 74°; which is not more than half a degree greater than the present magnetic dip at this place. Before 9h. 26m. there was but little undulation in the streamers, but about this time the Auroral waves began to show themselves, and soon flashed up towards the zenith with great magnificence. Low in the north, we saw at this time, what appeared to be short dark columns rising across the intensely luminous band which lay there, and then almost

instantly vanishing. This was often repeated. The southern part of the heavens was occupied with streamers to very unusual extent. The arch bounding the streamers on the South gradually descended, so that at 10h. its vertex was not more than 10° above the horizon. We were consequently led to infer that this occurrence extended very far to the south of us, which has been found to be the fact.

At 7h. 37m. I stationed within the house, a surveyor's compass, so that the needle coincided with the N. and S. points. At 8h. 7m. it stood at 30′ W. of N. At 9h. 7m. a splendid red blaze in the E., needle N. 30′ E.: 9h. 27m. needle 0. At noon on the 4th, the needle stood at N. 1° 30′ W., so that, (if we assume, as is most probable, that the needle had then regained its usual place,) its north end was not observed during the Aurora, to be carried to the west of its mean position. Circumstances rendered it inconvenient to retain the instrument any longer in the place it occupied during the Aurora, so that it can not be confidently asserted that the influence of the Aurora was entirely ended at noon on the 4th. The needle is much less sensitive than that of the variation compass formerly employed. Of course I can not compare the magnetic effects of this display with those of other great occasions of this kind. During the evening, the temperature was from 70° to 60°. At 9h. the dew point was 58°, the air being 65°.

We discontinued our observations a little after 11h. at which time the display had greatly declined. A person who was abroad after midnight, informed me that about 1 A. M., (4th,) the spectacle was, if possible, more splendid than before. At 4 A. M., I found numerous streamers in active undulation, about the Northern horizon; but not reaching to a greater elevation than 20°.

During the night of Wednesday, the 4th, the sky was densely overcast. A moderate Auroral display was seen at Albany, N. Y., at Middlebury, Vt., and probably at many other places where the state of the weather permitted observation.

2. *Nashville, Tenn.* N. lat. 36° 9′ 33″; W. lon. 86° 49′. The following observations are contained in a letter to Prof. Silliman from Prof. James Hamilton, of the University of Nashville. "Although a resident in this city for more than six years, between 1827 and 1835, I have never seen so beautiful an exhibition of the Aurora Borealis, as that which occurred in the evening

of September 3, 1839; nor have I been able to learn that any of the oldest inhabitants remember one of equal magnificence. The late display was but little inferior to those I have observed in New Jersey, three times within the last four years. About 7 P. M., the northern sky appeared unusually bright, as if affected by lunar twilight. A large bank of vapor or thin cloud was discovered in the N., gently declining toward the E. and W. points of the horizon, and extending perhaps 30° in each direction. A similar bank of smaller dimensions was seen in the N. E., but less bright than the Northern. In a few minutes, the upper edges of both banks, but especially of the Northern, had a whiteness resembling the enlightened disk of the moon in its greatest splendor. The bank was at this time about 12° in height as determined by a theodolite. At 7h. 25m. a white streamer about 2° in width, arose from the bank about N. 6° E., and shot upwards through the Pole star as far as the zenith, being rather convex on the Western side. Others appeared immediately on both sides of it, passing through or near Ursa Major and Cassiopeia. The bank in the N. E. exhibited as yet no coruscations. At 7h. 45m., the columns had become larger and more numerous. One embraced Ursa Major, and another Cassiopeia, without farther extension horizontally. These were both of a brilliant crimson color, and remained nearly stationary for a considerable time, while the intervening column became faint. A westward motion was soon after observed in three principal columns, and about the same time a diminution in the brightness of the red ones. On this last occurrence, thin horizontal clouds of a red color were seen crossing the columns at an altitude of 30°, which however soon disappeared. When the northern bank possessed less energy, the Northeastern sent up to the zenith an intensely red column which continued to glow until nearly 9h., alternating however in brightness with those in the N. The Northern coruscations ceased about 9 P. M., and the other bank gave forth afterward but few and less vivid streamers. Before 10h. these had also ceased, yet the northern bank continued to exhibit its silvery edge; and another display occurred after midnight. The Northern bank attained an altitude of 22½° at 8h. 15m., and was about 3° higher at 8h. 40m.

"A very brilliant white column, 1° wide, and 3° W. of Arcturus, appeared to have undulations in the directions of its length

for a considerable time, as if caused by the gentle flow of a fluid on its surface. The first column from the N. was evidently either in or very near the plane of the magnetic meridian. The banks continued to increase along the horizon until 9 P. M., when they extended from the E. to within 10° of the W. The extremities were not bright, but had the usual appearance of light clouds. At this most westerly point, a shower had arisen about sunset which had been driven toward the S. W., and during the Aurora flashes of lightning at a great distance were occasionally seen. These became less and less vivid, the storm being driven away by a N. E. wind, blowing at the rate of three miles, and increasing to about six miles an hour during the phenomenon. The needle (about 10 inches long, and very sensitive,) vibrated through an arc of 1° 10′, while the columns were apparent, and on the following morning it had rested in an intermediate position only 20′ W. of its greatest eastern limit during the evening. The plate of an electrical machine, in an adjoining room, showed more than usual activity, giving after two turns, pungent and loud sparks to the knuckles three inches distant. The season has been exceedingly dry since the middle of July.

"Taking the direction of my transit telescope, I found the magnetic variation this day, (Sept. 7, 1839,) to be 5° 56′ E."

3. At *New Orleans, La.*, (N. lat. 29° 58′) the Auroral display was quite conspicuous, and appeared so much like a large conflagration, that the fire engines were called out to extinguish the flames. The altitude of the streamers is not mentioned. No corona was probably formed at this place. Being desirous to ascertain how far south a corona was visible, I made special inquiries of a friend at *Claiborne, Ala.*, (N. lat. 31½°) where the Aurora was very splendid, and learn that it could scarcely be said that a corona was formed there, although several times the Auroral columns were nearly united overhead. It is probable that a corona might have been seen within a hundred miles north of this.

4. *Carlyle, Ill.* (N. lat. 38½; W. lon. 89½.) Prof. John Locke has published in the Daily Missouri Republican, St. Louis, Sept. 8, 1839, a description of this Aurora, from his own observations. The display was of the most splendid character, and the point to which the streamers converged was determined by him to coincide exactly with that to which the dipping needle is there directed. Dr. L. had a few days previous found the magnetic

dip at Louisville Ky., to be 70° 8′, and on the 8th of Sept., he as ertained the dip at St. Louis to be 69° 32′.*

5. Throughout *England* the Aurora of September 3d, is described as most gorgeous. A confused and rhetorical account contained in a London paper of Sept. 4, (copied in N. Y. Journal of of Commerce, Oct. 12,) states that the Aurora "had a most alarming appearance, and was exactly like that occasioned by a terrific fire. The consternation in the metropolis was very great, thousands of persons were running in the direction of the supposed awful catastrophe. * * * At two o'clock in the morning (4th) the phenomenon presented a most gorgeous scene, and one very difficult to describe. The whole of London was illuminated as light as noonday, (!) and the atmosphere was remarkably clear. The southern hemisphere though unclouded was very dark, but the stars which were innumerable shone beautifully. The opposite side of the heavens presented a singular, but magnificent contrast; it was clear in the extreme, and the light was very vivid. There was a continual succession of meteors which varied in splendor. They apparently formed in the centre of the heavens, and spread till they seemed to burst; the effect was electrical, myriads of small stars shot out over the horizon, and darted with that swiftness towards the earth that the eye could scarcely follow the track; they seemed to burst also, and throw a dark crimson vapor over the entire hemisphere. * * * Stars were darting about in all directions, and continued until 4 o'clock, when all died away."

From this description some have imagined that there was actually during this Aurora, a shower of shooting stars, similar to that seen on the 13th November, 1833. Although it is doubtless possible that such a meteoric shower may occur on the 3d of September, yet the statement above given, unsupported by other testimony, is altogether inadequate to establish the fact. This is evidently a loose and overcharged description, and it is entitled to a literal interpretation about as much as is an article professedly on the "November Asteroids," which was published in a London paper in November, 1838, in which it is asserted that "several stars of an ordinary size" were seen "shooting *from their original spots*, and falling apparently to the earth."

* The statement of the altitude of the corona as observed in Brown Co., Ill. (p. 147 of this Journal,) is doubtless incorrect. The estimate was probably made by the eye; and in such circumstances an error of even 17° is not surprising.

ART. VII.—*Abstracts of Meteorological Observations made at St. Johns, Newfoundland, and at Canton, in China: with some Notice of the Half Yearly Inequalities of Atmospheric Distribution, which appear in these Observations;* by W. C. REDFIELD.

THE annexed summary of meteorological observations at St. Johns, was kindly furnished by Joseph Templeman, Esq., having been printed by him for circulation. The summary for ten years at Canton, in China, was obligingly forwarded by John Slade, Esq., and has appeared in the Canton Register. A comparative half yearly analysis of these observations, and of those made by me at New York, is herewith submitted.

Observations at Newfoundland.

The observations at St. Johns include a period of five years, ending with 1838. The barometer, we are informed, is 140 feet above the sea level. The annual mean of the barometer, deduced from these observations, is 29.735 inches; while the mean of my own observations near the sea level at New York, for the same period, is 30.111 inches:*—showing a difference in the mean atmospheric pressure of 0.376 inch; or more than one third of an inch of the barometric column.† Part of this difference, equal to about 0.180, is due to the difference of elevation of the two instruments; which when added, gives 29.915 inches for the sea level at St. Johns. If we assume the annual mean at the two places to be equal, there still remains a discrepancy of 0.196, or $\frac{1}{5}$ inch, nearly, to be accounted for. In the absence of more definite information concerning Mr. Templeman's barometer, I am inclined to ascribe this discrepancy to the stretching of the leather which forms the bottom of the cistern, while in a moist

* At a mean temperature of the mercury of about 68° or 70° F.

† I had recently an opportunity to compare the adjustment of my glass-cisterned barometer with the standard of the Royal Society, as transmitted by means of one of Newman's best iron-cisterned barometers, in the care of Lieut. Riddell, R. A., who has charge of the Magnetic Observatory which is now established in Canada. The height of the mercury by the scale of my instrument was found to exceed that of the standard barometer by a mean of 0.015 inch: which falls a little short of the permanent allowance I had made for the capillarity of the tube; the diameter of which is four fifteenths of an inch.

state, or while screwed up for safe transportation; which are the most common causes of error in the adjustment of the scale to its proper height in barometers. Now as the mean annual pressure at the two places, at the sea level, is presumed to be nearly equal, we may add 0.376 inch, or three eighths of an inch, to all the results in Mr. Templeman's summary, for the purpose of comparison with the observations at New York.

With this assumed correction, we find that the mean height of the barometer at St. Johns, at the sea level, for the five *half years*, which include the months of November, December, January, February, March, and April, which takes in the winter period, is 30.039 inches: while the mean of the five half years which include the remaining months, is 30.184 inches. The mean pressure of the half year which includes the summer, we here perceive, *exceeds* that which includes the winter, by the amount of 0.145 inches; or *one seventh of an inch*, nearly.

At New York, I find on the contrary, that the mean pressure of the half year which includes summer, for the same period of time, is *less* than that of the half year which includes the winter by 0.044 inch; or something less than $\frac{1}{23}$ of an inch: the mean for the winter half years being 30.133, while that for the summer period is 30.089. There appears no reason to doubt the accuracy of these results, in either case.

This analysis shows also an average difference of pressure at the two places for the same half year; assuming the same annual mean: the inequality for the winter period being 0.094 inch, or nearly one tenth of an inch greater at New York than at Newfoundland; while for the half year that includes summer, which exhibits the least fluctuations of pressure, and in which the equilibrium of the atmosphere is least disturbed by violent winds, the mean pressure is 0.095 inch greater at St. Johns than at New York.

It appears from the table, that the extreme *range* of the barometer at Newfoundland during the five years was 2.54 inches, or *two and a half inches*, nearly: while at New York for the same period, as corrected one fortieth for variation in the cistern, it was 2.265 inches; or *two and a quarter inches*, nearly. The difference of latitude in the two places is 6° 52′; the difference of longitude 21° 22′; both places being on the western margin of the same ocean.

Observations at Canton.

If we now turn to the observations at Canton, we shall find the mean half yearly results for the same months, for ten years, as follows: viz.

Mean pressure of ten half years, November to April inclusive, ... 30.140 inches.

Mean pressure of ten half years, May to October inclusive, ... 29.868 inches.

Thus, at Canton the mean pressure of the winter half year exceeds that of summer, 0.272 inch, or more than *one fourth of an inch.* The latitude of Canton is 23° 07′ N., being nearly in parallel with the north side of Cuba and part of the Bahama Islands: lon. 113° 14′ E. The mean height of the barometer for the ten years observed at Canton, is 30.005 inches; but if we add a correction for an assumed elevation of 40 feet above tide, it will be 30.051 inches. We may infer, therefore, that there is little error in the adjustment of the scale of inches in this barometer.

Assuming the same mean annual pressure for Canton as at New York, the following comparison of the half yearly results at these two places may be instituted.

	Winter half year.	Summer half year.
Mean at New York,	30.133	30.089
Mean at Canton, as adopted,	30.246	29.974
Excess at Canton,	0.113 in.	Excess at N. Y., 0.115 in.

The inequality at these places for the two periods, being the same in kind, but differing in degree by more than *one ninth of an inch;* the inequality being greatest at Canton.

If the results at St. Johns, Newfoundland, be compared in like manner with those at Canton, they will appear as follows:

	Winter half year.	Summer half year.
Mean pressure at Canton,	30.246 in.	29.974 in.
Mean do. at Newfoundland,	30.039	30.184
Excess at Canton,	0.207 in.	Excess at N. F., 0.210 in.

These results are different in kind and the inequalities greater than those between Canton and New York: the mean inequalities being more than *one fifth of an inch.*

The inequalities of pressure in the opposite seasons at Canton will appear more strongly, if we omit the months of April and October, which have nearly the mean pressure of the year. We have then a mean for the five months of the northerly monsoon or winter period, of 30.178 inches: the mean for January being as high as 30.24 inches. But for the five months of the southerly monsoon we find a mean of only 29.836 inches; and the mean of July and August is still lower, being 29.80 inches. We have thus an inequality of 0.342 inch: more than *one third of an inch*, for the average period of the two monsoons; while as between January and July and August, in the opposite monsoons, we have the still greater difference of 0.440 inch; approaching to *half an inch* of the barometric column. I have alluded to this extraordinary inequality of barometric pressure, on a former occasion.*

In regard to the prevalent winds at Canton, and their state of humidity, we perceive that the greater number of rainy days and the greatest depression of the barometer, accord nearly with the period in which the southerly monsoon most steadily prevails. The smallest number of rainy days and greatest atmospheric pressure accord equally with the prevalence of the northerly monsoon.

At New York, and also at Newfoundland, the tendency of the winds and the distribution of rain, throughout the year, is probably more uniform than at Canton; but the region about Newfoundland is believed to be somewhat remarkable for its humidity, particularly in the summer months; while, as we have seen, in the latter season the barometer maintains more than its average elevation.

In view of all the facts presented, therefore, there appears no good reason to ascribe to hygrometric considerations, in any considerable degree, the great differences in the equality of atmospheric distribution which are here brought to our notice.

New York, December 3d, 1839.

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* See this Journal, Vol. xxxiii, p. 264.

1. *St. Johns, Newfoundland. Meteorological Table for five years ending Dec. 31, 1838. From observations made by Joseph Templeman of the Colonial Secretary's Office.*

		January.		February.		March.		April.		May.		June.	
		Therm.	Barom.	Therm.	Barom.	Therm.	Barom.	Therm.	Barom.	Therm.	Barom.	Therm.	Barom.
		degs.	inches.	degs.	inches.	degs.	inches.	degs.	inches.	degs.	inches.	degs.	inches.
1834.													
Mean of the Month,		17¼	29.63	16⅝	29.75	20⅝	29.73	30½	29.60	39½	29.85	49½	29.87
Extremes,	Highest,	36	30.30	40	30.35	46	30.30	46	30.42	57	30.40	76	30.27
	Lowest,	—7	28.69	—14	28.50	—6	28.80	13	28.80	24	29.35	30	29.35
Mean of Extremes,		14½	29.45	13	29.425	2[illegible]	29.55	29½	29.61	40½	29.87	48	29.81
Days on which extremes occurred,	Highest,	18th	30th	11th & 16th	10th & 18th	22d	8th & 28th	25th	5th	10th	16th	8th	6th
	Lowest,	31st	22d	6th	27th	3d	14th	17th	29th	30th	1st	18th	15th
1835.													
Mean of the Month,		24½	29.67	25½	29.81	22⅝	29.75	33⅜	29.61	39½	29.64	48	29.83
Extremes,	Highest,	44	30.20	47	30.44	47	30.49	51	30.17	60	30.30	73	30.11
	Lowest,	—5	29.75	0	28.78	—2	28.62	19	28.95	25	29.09	29	29.35
Mean of Extremes,		19½	29.47	23½	29.61	22½	29.55	35	29.56	42½	29.70	51	29.73
Days on which extremes occurred,	Highest,	1st	6th	28th	15th	23d	8th	7th & 8th	5th	30th	13th	21st & 28th	28th
	Lowest,	4th	1st	3d	5th	12th	18th	5th	15th	23d	3d	10th	5th
1836.													
Mean of the Month,		26	29.81	24½	29.78	23⅜	29.77	31⅜	29.81	37	29.76	45	29.85
Extremes,	Highest,	48	30.42	48	30.52	55	30.30	60	30.37	66	30.10	80	30.22
	Lowest,	4	29.04	1	28.78	2	28.90	14	29.20	18	29.30	27	29.20
Mean of Extremes,		2[illegible]	29.73	24½	29.65	28½	29.60	37	29.78	42	29.70	53½	29.71
Days on which extremes occurred,	Highest,	25th	24th	22d	20th	11th	10th	22d	21st	19th	27th	7th	6th
	Lowest,	17th	26th	27th & 28th	15th	19th	2d	12th	2d	3d	5th & 8th	3d	16th
1837.													
Mean of the Month,		26⅜	29.29	20¼	29.46	27¾	29.89	37¼	29.50	39½	29.64	45½	29.67
Extremes,	Highest,	46	29.95	40	30.04	45	30.44	60	30.05	60	30.22	73	30.02
	Lowest,	0	28.76	—6	28.67	2	29.15	25	28.80	25	28.95	29	29.34
Mean of Extremes,		23	29.30	17	29.35	23½	29.80	42½	29.42	4[illegible]½	29.58	51	29.68
Days on which extremes occurred,	Highest,	23d	30th	28th	27th	11th	5th	29th	24th	23d	20th	22d & 25th	1st
	Lowest,	28th	8th	7th	13th	5th	27th	23d	6th	2d	2d	3d & 20th	12th & 30th
1838.													
Mean of the Month,		22½	29.87	17½	29.13	26	29.71	33¾	29.72	41¼	29.85	52	29.79
Extremes,	Highest,	49	30.72	40	29.78	47	30.48	61	30.27	65	30.2[illegible]	73	30.30
	Lowest,	—6	28.80	0	28.30	3	28.65	12	28.85	28	29.31	30	29.35
Mean of Extremes,		22½	29.76	20	29.04	25	29.56	36½	29.56	46½	29.80	51½	29.82
Days on which extremes occurred,	Highest,	8th	26th	17th	14th	16th	22d	20th	14th	30th	31st	11th & 26th	1st
	Lowest,	24th	31st	17th	17th	4th	28th	24th	2d	6th	16th	19th	4th
Monthly means for 5 years,			29.654		29.586		29.770		29.648		29.748		29.802

1. *St. Johns, Newfoundland. Meteorological Table for five years ending Dec. 31, 1838. From observations made by Joseph Templeman, of the Colonial Secretary's Office.*

	July.		August.		September.		October.		November.		December.	
	Therm.	Barom.	Therm.	Barom.	Therm.	Barom.	Therm.	Barom.	Therm.	Barom	Therm.	Barom
1834.	degs.	inches.	degs.	inches.	degs.	inches.	degs.	inches.	degs.	inches.	degs.	inches.
Mean of the Month,	58 1-7	29.84	58½	29.86	56	29.86	47¾	29.95	33½	29 68	25¼	29.79
Extremes, Highest,	86	30.28	78	30.25	74	30.32	70	30.30	52	30.13	45	30 67
Extremes, Lowest,	37	29.48	36	29.40	36	29.50	28	29.40	15	29.11	4	28.98
Mean of Extremes,	61½	29.88	57	29.82	55	29.91	49	29.85	33½	29.62	24½	29.82
Days on which extremes occurred, Highest,	15th	20th	25th	31st	3d&4th	14th	10th	12th&19th	15th	17th	15th	19th
Days on which extremes occurred, Lowest,	1st	1st	10th	8th&14th	16th	7th&10th	26th	10th	29th	8th	29th	7th
1835.												
Mean of the Month,	58½	29 80	61	29.87	55.56	29.90	46½	29.98	31 5-6	29.58	24½	29.52
Extremes, Highest,	80	30.20	81	30.25	77	30.27	70	30.45	54	30.15	46	30.15
Extremes, Lowest,	37	29 37	43	29.57	35	29.15	25	29.38	14	28 97	8	28.50
Mean of Extremes,	58½	29.78	62	29.91	56	29.71	47½	29.91	34	29.56	27	29.32
Days on which extremes occurred, Highest,	19th	21st	11th	16th	1st	13th	9th	20th	17th	15th	27th	20th
Days on which extremes occurred, Lowest,	12th	17th	7th	17th	16th	3d	27th	12th	22d&25th	21st	24th	3d
1836.												
Mean of the Month,	55¾	29.83	57½	29.88	49½	29.80	43¾	29 80	36¼	29.62	27½	29 80
Extremes, Highest,	81	30.11	78	30.14	74	30.33	71	30.30	61	30.23	47	30.55
Extremes, Lowest,	30	29.35	40	29 43	30	29.31	22	29.30	20	28.24	2	29.05
Mean of Extremes,	55½	29.73	59	29.78	52	29.82	46½	29.80	40½	29.23	24½	29.80
Days on which extremes occurred, Highest,	12th&14th	12th	2d	6th&12th	5th	7th	6th	2d	16th	9th	31st	25th
Days on which extremes occurred, Lowest,	2d	20th	29th	9th	24th	20th	31st	28th	19th	30th	23d&24th	1st
1837.												
Mean of the Month,	53	29.63	56¾	29.77	51¼	29 80	40½	29 86	37¼	29.73	23¾	29.49
Extremes, Highest,	72	29.98	78	30 13	75	30.20	63	30 46	60	30 28	37	30.25
Extremes, Lowest,	33	29.20	41	29.14	33	29 35	21	29.23	18	28 98	6	28 65
Mean of Extremes,	52½	29.59	50½	29.63	54	29.77	42	29.84	39	29 63	21½	29.45
Days on which extremes occurred, Highest,	16th&28th	31st	3d	14th	11th	22d	28th	20th	23d	1st	26th	28th
Days on which extremes occurred, Lowest,	12th	10th	31st	23d	20th	13th	19th	2d	30th	7th	17th&27th	12th
1838.												
Mean of the Month,	55¼	29.75	55½	29.74	52⅔	29.84	44	29 72	31	29.72	25¼	29.66
Extremes, Highest,	79	30.25	76	30.16	76	30.36	66	30 10	59	30 22	47	30.52
Extremes, Lowest,	38	29.34	33	29.05	32	29.23	25	28.98	12	28.97	2	29.00
Mean of Extremes,	58½	29.80	54½	29.60	52	29.80	45½	29.54	35½	29.60	24½	29.76
Days on which extremes occurred, Highest,	4th	25th	24th	30th	3d	13th	3d	11th	6th	11th	6th	31st
Days on which extremes occurred, Lowest,	21st	29th&31st	3d	27th	9th	20th	30th	29th	24th	25th	29th	19th
Monthly means for 5 years,		29.770		29.824		29.840		29.862		29.666		29.652

"*Remarks.*—St. Johns is in lat. 47° 34′ 3″ N. and lon. 52° 38′ 30″ W. The height of the barometer above the level of the sea is 140 feet. From the foregoing table it will be observed that in the peculiar climate of this Island the mean temperature of the month of September is very little below that of July, whilst that of October is nearly equal to that of June. The first fortnight in February is usually the severest part of the winter—in which period the thermometer in some seasons sinks to from 10° to 20° below the *zero* of Fahrenheit. It will also be seen that in the year 1836 there was only one month (August) in which frost did not occur. The temperature above shown is the mean of the maximum and minimum of every 24 hours commencing at 9 A. M. It generally happens, therefore, that the greatest degree of cold occurs on the *morning following* the date here shown. Where two dates are mentioned, it shows, of course, that the same *extreme* occurred on both days.

"As regards the barometer, it may be observed that it is scarcely ever steady for 6 hours together. Its oscillations are often great and sudden, sometimes as much as from 1½ to 2½ inches, in the course of 36 hours. These are greatest and most frequent in the winter months—during which period almost every variety of weather is experienced in the course of every *four* days. The barometer attains, during that interval, to the height of from 30.20 to 30.40 inches, the weather being calm and serene and the cold severe—the mercury soon indicates a change—a breeze springs up from the S. E. and increases to a gale with snow and drift. This is most frequently, although not always, succeeded by heavy rain from S. W. (the temperature, which in the morning was perhaps near or below *zero*, rising to above 40 degrees) and in a few hours the wind, which generally subsides after the rain, suddenly shifts to the N. W., with a strong breeze. The barometer (which on these occasions falls rapidly and almost always sinks to several 10ths below 29 in.) then begins to rise again, as rapidly as it had before fallen. At the turn of the barometer, the gale increases for a few hours, and then gradually subsides. The barometer very rarely rises above 30.50 inches, and has never, except on one occasion, during the above period of five years, fallen as low as 28.50 inches."

2. *Canton, China. Table shewing the Mean of the Monthly Range of the Thermometer and Barometer, from* 1829 *to* 1838, *both inclusive, with the predominance of N. and S. Winds, and number of Rainy Days, and the Average Monthly Range of the Thermometer and Barometer, and number of Rainy Days in* 1838.

1829 to 1838.					1838.								
					Thermometer.							Barom	Rainy days.
Month.	Therm.	Barom.	Winds N. S. Days.	Rainy Days.	Mean of night	Mean of noon.	Mean of night and noon.	Lowest.	Night.	Highest.	Noon.		
January, . .	$52\frac{1}{4}$	30.24	25. 6	6	50	59	$54\frac{1}{4}$	39	12th	73	1st	30.21	2
February, . .	55	30.17	18. 10	7	55	61	58	32	8th	72	3rd	30.20	7
March, . .	$62\frac{1}{4}$	30.11	17. 14	11	61	68	$64\frac{1}{4}$	46	6th	76	14,25,30,31st	30.05	10
April, . . .	70	29.96	12. 18	12	67	72	$69\frac{1}{2}$	50	9th	85	25th	29.96	15
May, . . .	77	29.89	10. 21	16	76	83	$79\frac{1}{2}$	67	4th	89	30th	29.88	19
June, . . .	81	29.87	4. 26	14	78	85	$81\frac{1}{2}$	72	13th	92	29th	29.83	20
July, . . .	83	29.80	6. 25	16	81	89	85	76	11th	96	16,17,18th	29.80	17
August, . .	82	29.80	10. 21	14	80	89	$84\frac{1}{2}$	77	24,29th	94	17th	29.83	11
September, . .	80.033	29.82	$17\frac{1}{2}.12\frac{1}{4}$	$10\frac{3}{5}$	77	$85\frac{2}{3}$	$81\frac{1}{3}$	72	13,25th	93	17th	29.84	14
October, . .	$73\frac{1}{4}$	30.03	$21\frac{8}{10}.9$	$4\frac{9}{10}$	67	78	$72\frac{1}{4}$	60	11th	86	5th	29.79	1
November, . .	$65\frac{1}{5}$	30.17	$23\frac{7}{10}.6\frac{2}{5}$	$3\frac{8}{10}$	$59\frac{2}{3}$	$70\frac{1}{3}$	65	44	26,27th	78	7,8th	$30.19\frac{1}{3}$	3
December, . .	57.134	30.20	$25\frac{1}{2}. 6\frac{1}{2}$	$6\frac{7}{10}$	$53\frac{4}{3}$	$63\frac{5}{3}$	58.145	32	18th	72	8,27th	30.22	7

The above observations were made from a self-registering instrument, by Gilbert, of London. The instrument is placed in the verandah of a house in Canton, built on a stone foundation, on the side of a creek, which washes the wall on the eastern side. The verandah has a northerly exposure, and is elevated about thirty feet from the ground; the instrument is suspended about five feet from the marble floor of the verandah and one inch from the plastered brick wall.

ART. VIII.—*Abstract of a Meteorological Journal for the year* 1839, *kept at Marietta, Ohio, Lat.* 39° 25′ *N., and Lon.* 4° 28′ *W. of Washington City;* by S. P. HILDRETH, M. D.

Months.	THERMOMETER.				Fair days.	Cloudy days.	Rain and melted snow.		Prevailing winds.	BAROMETER.		
	Mean temperature.	Maximum.	Minimum.	Range.			Inches.	100ths.		Maximum.	Minimum.	Range.
January,	35 33	66	−3	69	13	18	2	30	N. N. E., S. S. E.	30.00	28.95	1.05
February,	36.33	70	7	63	21	7	2	00	W. N. W., S. & S. W.	29.82	28.70	1.12
March,	42 66	74	−4	78	21	10	2	25	S. S. W. & N. W.	29.72	28.95	.77
April,	57.53	84	26	58	24	6	1	44	S. S. E. & N.	29.65	28.96	.69
May,	64 33	92	32	60	21	10	4	16	S. S. E. & W. N. W.	29.55	28.98	.57
June,	68.33	90	45	45	16	14	4	33	S. S. W. & W.	29.50	29.10	.40
July,	72.33	92	50	42	21	10	6	04	S. S. W. & W.	29.55	29.12	.43
August,	69.00	88	53	35	26	5	2	04	E. S. E. & N.	29.63	29.15	.48
September,	59.66	80	32	18	18	12	3	25	S. S. W., W. & E.	29.70	29.05	.65
October,	50.64	84	28	56	26	5	0	25	S. & S. E.	29.75	29.20	.55
November,	38.00	59	17	42	15	15	2	50	S. W. & N. N. E.	30.01	28.88	1.13
December,	36 33	57	7	50	6	25	2	16	W. N. W. & N. E.	29.52	28.80	.72
Mean,	52.54						33	32				

Remarks on the year 1839.—The mean temperature for the year 1839 is 52.54°, which is two degrees greater than that of 1838, and may be considered as about the mean for this place. The quantity of rain and melted snow is 33.32 inches; and is two inches less than that of the preceding year, which was considered as a remarkable one for the little rain that fell in the latter half of it, and is about nine inches less than the mean amount for this region. In the past year, however, the distribution of rain has been very equal, so that every month had its due share in such seasonable showers as to afford a good supply for vegetation, and the crops of all kinds of grain and grass were never more abundant. The mean temperatures of the four seasons are as follows, the winter being made up with the aid of December, 1838, which properly belongs to it.

Winter months,	33.27°	Spring months,	54.84°
Summer months,	69.88	Autumn months,	49.43

The winter was milder than that of 1838 by three degrees, and the spring warmer by five degrees. The summer was cooler by nearly five degrees, and far more pleasant and fruitful. Autumn varied but little from the preceding one. The pear and cherry tree were in blossom on the 11th of April, the apple on the

17th, and Cornus florida on the 24th. An unusual depression of temperature on the 4th of March, sinking the mercury to four degrees below zero, destroyed nearly all the blossom buds of the pear and the peach. Apples, and all the smaller fruits, were abundant. The severe storms in December, which visited the coast in the eastern states, were but slightly felt here. On the 15th, 22d, and 28th of December, we had falls of snow, accompanied with but little wind, amounting in all to about a foot. Thirty miles west of this place the ground has barely been covered with snow, to this time, the twentieth of January, while E. and S. E. as we approach the mountain ranges, it has fallen to a depth unprecedented for many years. The same great abundance of snow seems also to have attended the storms in the middle and eastern states.

January 20, 1840.

ART. IX.—*Description of a New Compensating Pendulum;* by WILLIAM GWYNN JONES, A. M.

DURING the latter part of the past year, while engaged in some interesting astronomical observations which required considerable accuracy, it was indispensable to procure a time-keeper whose rate would not be affected by the variations in the temperature of the weather, to which all such machines, of ordinary construction, are liable. The expensiveness of a chronometer which could be relied upon for such a purpose, rendered a resort to some more economical instrument desirable, if it could be depended upon. The gridiron pendulum as well as the mercurial one, both of which have been designed to effect this object, were found unsatisfactory; the former from the difficulty of procuring an exact adjustment of the different rods of which it is composed, so as to produce the desired counterbalancing expansion and contraction, and the mercurial pendulum proving upon experiment too sensitive to be relied upon. Under these circumstances, I contrived a simple arrangement for a pendulum, acting upon the principle of the lever, which performed with so much accuracy that I have been induced to present it to the notice of the readers of the American Journal, believing it will not prove uninteresting to those engaged in scientific investigations requiring great uni-

formity of action in a time-keeper. The arrangement of the parts is so simple as to be readily understood by any skillful workman, and as it is entirely free for the adoption of any one who may prefer its construction, I have prepared a description and diagram to render it intelligible.

Fig. 1.

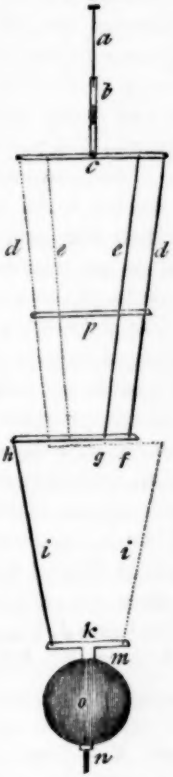

Fig. 1, shows the whole pendulum, the dotted lines representing similar parts to those on the opposite side, and are introduced to render the drawing more easily understood; *a* is a similar spring to that which is attached to the pendulum of an ordinary eight-day clock, and is firmly attached to the perpendicular brass bar *b*. Through *b* there is the usual opening for the guy-wire, which gives motion to the pendulum. This bar is firmly affixed to the transverse bar *c* either by riveting or soldering. On each end of the bar *c* there is attached a brass rod *d*, *d*, and one inch from each of these there is also affixed a steel rod *e*, *e*. These four rods pass through the bar *p*, which is intended merely to preserve them in their proper position, and is attached to the two brass rods by a pin passing through both, while the steel rods are allowed to move freely through the holes. At *f*, a transverse bar or lever is affixed to *d* by a loose pin passing through them, and the same attachment is made to the steel rod *e* at *g*. This bar is four inches long, three inches of which extend from *g* to *h*, and a similar one is attached to the dotted rod *d* and extends on the opposite side. At *h* there is another loose attachment to the rod *i*, which is of steel, and which is again affixed to the bar *k*. At *k* there is a permanent bar *m*, which passes through the weight *o*, and has the usual adjusting screw *n* at the bottom.

Rationale.—Suppose that by an increased temperature of 20°, the steel rods *e*, *e*, are expanded in length $\frac{1}{16}$ of an inch. The rods *d*, *d*, being of brass, and a small fraction larger than the steel, will expand $\frac{1}{8}$ of an inch by the same increase of temperature, it being an established theory with the best French chemists,

that the relative effect of the temperature upon the two metals is as 3 to 5, or nearly double the expansion in brass as in a steel rod of similar size. The outer rods then have expanded in length $\frac{1}{16}$ of an inch more than the inner rods. It will be apparent from a slight inspection of the drawing, that as the brass rod *d* and the steel one *e* are attached by a connecting pin to the transverse bar *f h*, that by *d* expanding more than *e*, that *f h* becomes a lever, *g* being the fulcrum, and as *g h* is three times as long as *f g*, consequently if *d* be expanded $\frac{1}{16}$ more than *e*, the end *h* will be elevated $\frac{3}{16}$ of an inch, and thereby raise the weight *o* $\frac{1}{8}$ of an inch more than the expansion of *d* has depressed it. This increased elevation is intended to allow that the spring *n*, the bar *b*, the rod *i*, and the bar *m*, unitedly, will expand $\frac{1}{8}$ of an inch also, and if so, it must be apparent that the whole pendulum has preserved its equilibrium and remains precisely of the same length as if no change had taken place in any of its parts.

Fig. 2, shows a perpendicular view of the transverse bar *f h*, arranged so as to admit the corresponding bar for the other side to work freely, and at the same time preserve the four upper rods upon a line with each other, which, as the levers intrude within each other, could not be done without the recess as shown in the section. The same letters correspond to the same parts in Figs. 1 and 2. The dotted lines in Fig. 2, are intended to show the relative position of the lever which is attached to the dotted line *d*, Fig. 1, in regard to the other.

Fig. 2.

Baltimore, Md., 1834.

ART. X.—*Some account of* ITHIEL TOWN'S *improvement in the construction and practical execution of Bridges, for Roads, Railroads, and Aqueducts.*

THE improvement which is described in the following paper, was secured by patent in 1835, and is intended as a general system for the construction of bridges, whether of wood entirely, or of cast or wrought iron, over rivers, creeks, harbors, &c., where required for any kind of conveyance; either with wide openings between the piers, of two hundred to four hundred feet, or with

smaller openings; whether the piers and abutments are of stone, framed timber upon mud-sills, or piles driven into the bed of the river.

Economy of expense, great strength, durability, and a level road-way, united in a general system of building bridges, &c., suited to any part of the United States, which may be constructed of such materials as can be obtained in any part of the country, are what is attempted, and it is confidently hoped have been accomplished.

The subject is here explained in a general manner, with remarks, also, on some of the disadvantages which have heretofore attended the other modes of construction, which, by this improvement, have been guarded against or obviated.

A quarto pamphlet has just been published, and may be had at the principal bookstores in New York, giving a very minute description and explanation, by engravings and otherwise, of the principles, as well as the practical and mechanical execution, in detail, of all that appertains to the construction of the patentee's latest improvements.

A model may be seen at the Patent Office, Washington City, and at the American Institute, back of the City Hall, City of New York, at which latter place the patentee may be found, or letters post-paid, directed to him there, will be promptly attended to.

The great and increasing use of wooden bridges, and the frequent obstruction by freshets and other accidents, in this extensive country, intersected with its rivers, immense both in number and magnitude, render unnecessary any apology for improvements introduced; especially if either the great annual amount of capital expended, or the important daily use of bridges for roads, railroads, &c., be considered.

The patentee's former improvement in bridges, in 1821, was published in the American Journal of Science of that year, and subsequently in a pamphlet, but too brief for that correct illustration of the subject which is to be found in the pamphlet now referred to, for this last improvement, or in the general manner which here follows in describing it. It consists principally in the introduction of two, or in some cases more, series of truss-braces, diamonds or lattices, by which two very important advantages have been realized, neither of which, it is believed, could be realized to an equal extent in any other manner, viz.

1st. An immense additional strength may be obtained, with much less quantity of plank in the string-pieces, in proportion to the strength, stiffness, and durability thereby gained; especially, as double the number of tree-nails pass through all the string-pieces which are in the middle of each truss, or between the two series of truss-braces, and thereby secure the splices of the plank composing the string-pieces, in a much more effectual manner, against their *tension strain*, which is great, and therefore requires the best possible security to counteract it. This manner is effectual, even without the aid of iron, to a greater degree than is practicable in any other manner known in practical mechanics.

2. The great evil, so much complained of in the first mode, by all bridge builders, viz. of keeping the trusses straight, or from warping, twisting, or leaning sidewise, is by this improvement entirely done away; it being more easy to keep the trusses in their true position, and have them remain so, than in any other mode; because, first, the trusses are of greater thickness, and therefore less liable to admit of any *curve*, twisting, or deviation from their true position. And secondly, because the trusses run horizontally, they are less liable, even with the same thickness, to get out of their straight and vertical position, than would be the case with the arched bridge, which, by rising higher at the crown of its arches, gives much greater leverage to its own gravity, and to the winds, for a deviation from its true position, to that of a curved or twisted one, which might impair its strength or safety.

It may be stated, as it is believed by the patentee, that with this last improvement, his mode of construction, for all important purposes, is such as to avoid all possible objections of every kind, for whatever purpose it may be used; but more especially for bridges of very wide spans, as also for railroads and aqueducts, which indispensably require great strength, and a level road-way, which other bridges would not admit of, to an equal degree, however much might be expended in their construction.

The patentee is aware, that some engineers have by some means obtained the opinion, that this improvement, though good, and very strong for a proper extent of span, as well as more economical than other modes, is not as well suited to very wide spans, as possibly some other mode might be! There could not, most certainly, be formed an opinion more erroneous. With

twenty years' experience in bridges, the *patentee* feels confident of no one fact, in science and practical mechanics, more than this, that the wider the spans are adopted, the greater, by far, is the strength and durability of this last improvement, when suitably executed to such width of span, compared with any other mode of construction now in use. If, indeed, this were not the fact, beyond a doubt, in the mind of the patentee, he certainly not only would not trouble himself with its introduction into public use, but would promptly admit that this, or any other mode not possessed of such principles, would neither be entitled to the credit of a "general system," or be possessed of any other advantages worthy of public confidence or patronage.

It has ever been his opinion, even from the *first*, that this mode of combining materials, when properly perfected by practical experience, was such as not only to possess all the advantages that science could render in its mathematical principles, but also to have the immense advantages of the application, in its mechanical execution, of materials, which may be procured in any part of the country, with the greatest ease, dispatch, and economy.

It is also found, in a long practice of this particular principle, that the advantages in the mechanical execution, by using light timber, combined of sawed planks, and by a distribution, therefore, of the strain or weight to be overcome, into such an almost innumerable number of nearly equal parts, that the strength of any material, even the *softest pine*, becomes abundantly sufficient to sustain its portion of such strain; and the mode, also, of securing each and every part of the construction, without the aid of iron, becomes practicable—so amply sufficient as to ensure strength, rigidity, and durability, to a degree, most certainly not to be even very nearly approached by any other system of combination and mechanical execution in practice. The great and equal distribution of the material, in the sides or trusses of the bridge; the immense number of intersections or crossings of the timber, in each truss, which are, each and all of them, thoroughly secured by four, three, or two *hard wood* tree-nails, of two inches in diameter, according as each particular intersection may require, in the importance of its situation for the purpose of bearing its part of the strain; and, lastly, and by no means the least important, the advantage gained in this mode, which has never been

accomplished or claimed for any other arrangement, viz. of having all the strain or weight, of every description, which the bridge can be made to receive or sustain, whether it be its own weight, which is generally the greatest, or any other, such as droves of cattle, or trains of cars, with locomotives, &c., so distributed, that in all cases such strain or weight is sustained, in due proportion, by every piece of plank composing the sides or trusses, in a direct end-grain strain, viz. either a tension or pulling strain, or a thrust or pushing strain. In both instances, of course, therefore, the strain is exactly in the direction of the length of the pieces. The great advantages of this one particular point, in the construction of bridges, is very important; and in wide spans, this importance is increased to a degree that can only be duly appreciated by the most experienced and sound practical engineers.

That the plank composing the trusses is liable to shrink, is true; but as the strain is, in all important respects, in the direction of the length of such planks, it is therefore evident, that such shrinking cannot produce any effect, unless it be to do good, by holding more firmly to the three or four tree-nails, which pass through each plank, in several places, and, of course, cannot be affected in any other manner than to be more tight on the tree-nails, in the direction of the width of the plank, but without alteration in the direction of their length, which alone could have the least effect to do injury. What is stated in regard to shrinkage, is also true, to a greater extent, in that of the mashing or compression of timber; in this arrangement of construction, there is not the least tendency whatever to the compression of any of the plank composing the trusses, by any strain to which they are liable in their own support, or the support of any other weight; except, only, where the trusses rest upon the piers, and this only by its own gravity, and not by any strain or compression occasioned by the mode of construction, as is the case in all bridges of other modes of construction, where posts are introduced for the insertion of braces, by tenons and mortices, and where, of course, the accumulation of shrinkage, and the compression of the posts, by a great strain on a few points, both contribute to operate towards the weakening of the bridge, so as to give it a vibratory motion, which, in time, is sure to do violence to a bridge, and, in the end, destroy it, or occasion large repairs, and the con-

stantly tightening of wedges and other parts; which, however, cannot possibly raise a bridge which has once settled, or become weak, from such looseness of its parts, and the consequent vibrations thereby occasioned.

Nor is cast iron, whatever expense for it may be incurred, any more than a very partial remedy; for still, the wood will both shrink and be, by the great pressure of the parts, compressed; so that in a span of 100 feet, if made in a shape of parallelogram trusses, with a tie-string piece at the bottom, to prevent a horizontal thrust or pressure against abutments and piers; and, as usual in bridges depending on exact and expensive execution of carpentry, with king-posts at every eight or nine feet distance, and filled up between them, with any kind of double braces, whether with iron footings, or even without them; still the shrinkage and compression, *both*, of each post, must take place, and, consequently, the accumulation of shrinkage and compression of all the posts. Some eleven or twelve, in the hundred feet span, will operate to one end, viz. to give the bridge motion, by use, and a depression to a line below its first position. By wedges, carefully driven, and with the most prompt attention at all times to them, a part of the evil may be prevented, but by no means can it be fully prevented, even in so small a space as 100 feet. When spans, however, of 150, 175, 200, and from 200 to 300 feet, are required, and, of course, the strength requisite for the support of such a span, so very much greater, while, at the same time, the accumulation of shrinkage and compression of timber becomes twice or thrice as great as in the span of 100 feet, from the fact that so many more such posts are necessary to its construction, it must be, beyond all doubt, perceived, that such constructions, from these disadvantages in their execution, by which they are inevitably exposed to such disadvantageous frailty in the material, for which there is no remedy, and which the mode of using or combining does not provide against, or remedy in the execution, must be defective and of short duration.

Hence it appears, to a certainty equal to mathematical, that, at no reasonable expense can there be bridges of the other modes of construction of wide spans, constructed with an arrangement of the materials, such as to admit so much pressure or strain, on comparatively a few points; and, at nearly all of them, the strain, depending so much on a pressure against the side grain of a ma-

terial so frail, and so certain to be operated upon by two such formidable evils as shrinkage and compression, and that, too, in the accumulated quantity of from twenty to thirty posts, and twice or thrice the number of braces, all of which also admit of the same evil, to a very considerable extent. Time has shown, and will in future show, the truth of these observations, to such an extent as will fully remedy the evil.

The original mode of using the arch, by Burr, Wernwag, Field, and many others, it must be admitted, had the very important advantage of sustaining the most important portions of the strain, in the direction of the length of the materials, as in the arch-pieces, which, indeed, were the main support of the structure. In these constructions, in which the arch is so conspicuous for the strength and beauty of the superstructure, (for beautiful, it must be admitted the arch is, when applied with good taste,) there seem to be evils too great to be overcome, by the most profound science, or the most refined practical experience in execution. Some of which are—

1st. The great expense of construction, too great, by far, to be incurred, except at a few points, where the great importance of the work, and a command of great wealth can be united.

2d. The great horizontal thrust against abutments and piers, requires great expense in its construction; and even then, when an accident destroys one arch, the others, by their own gravity, destroy not only themselves, but their piers also, to any length to which the bridge may extend. In bridges of many arches, therefore, it would be fearfully imprudent to construct them in this manner, even if means might be had for the purpose. Two bridges of this kind were erected over the Schuylkill, at Philadelphia, many years ago; one of three arches, the other of one arch; and although so short, each one cost a very large sum to its proprietors. A third, for the Western Railroad, was erected six or seven years ago, a short distance above the other two, on fine stone piers of solid masonry, laid in coffer-dams. It has five or six arches, but in their construction the more modern mode of attempting to add what is termed a tie, to the arches forming a level road-way, and at the same time, relieving the arches from the horizontal thrust or pressure against abutments and piers. This mode has recently been much practised, but it is very questionable whether, in many instances, this kind of tie for the

safety of the arches, piers, &c., is sufficient to save either the bridge or the piers, in the event of the destruction of one of the arches, or of one of the piers. A case in point, tested the truth of this statement, at Pittsburg, in 1832. A high freshet, in the Ohio, forced away one pier of one of the long bridges at that place, by which two arches were destroyed; and although the bridge was intended to be secured with tie-string pieces, effectually, at or near the foot of each arch, yet such was the effect when, by the absence of two arches, the whole counteracting pressure of the arches was destroyed, that the patentee found, by careful examination, soon after the destruction of the two arches, that all the other arches were giving way and settling, nearly or quite across this wide river. The giving way of these ties, on which the road-way was placed, was so great as to require prompt and ample additional support, by props and otherwise, to keep some of the arches from falling; and even then, they settled so as to push nearly all the piers from their true position, in a horizontal direction, so as to produce cracks and violence, which was plainly seen; but was greatest in those piers nearest to the part broken away. These piers were not very high, and yet were large in proportion, and of hewn stone on the exterior. The remaining parts were much injured; and, by great care and good fortune, were saved from a general destruction. This, then, is a very strong proof, that such mode or intention to secure the arches against so formidable an evil, is not generally done so as to render them safe, in case of such an accident. That all bridges should be safe in this respect, especially long ones, is of so great importance, as not to admit, with prudeuce, of any possible doubt or question on the subject.

3d. The arched bridge requires great weight of timber; most of which, large enough to be subjected to the dry-rot.

4th. The feet of the arches generally stand against the abutments and piers, at a point much lower than the floor of the bridge. By this means, they are exposed to rains in windy weather, and to dampness from the piers; so much so, as to cause their decay in twenty or twenty-five years. This was the case with the bridge at Trenton, over the Deleware; the feet of the arches were renewed, at very great expense, about 1832; and from the great exposure to the weather, of this bridge, above the floor, it will probably require rebuilding, in the upper parts, within

thirty years, unless better protected from the weather. It has been stated, that it was left so exposed to the weather to render it secure against wind; most certainly a more mistaken, absurd, and unphilosophical idea, could not be entertained. There is much less danger from winds to bridges, when covered completely from the weather, than in almost any other kind of building of wood; because they are, when of considerable length, much secured by combination, into one mass, their whole length; they are, also, very heavy, compared with most other wooden structures, and have great strength, as well as a long and continued connection of parts, by which means, one part is weight and support to the other; they are never high enough to present a very deep volume to the wind; and, lastly, the wind passes under them so freely as to give itself vent, and if the length presents a wider resistance to wind, the great length of heavy and well combined materials is an amply sufficient anchor of safety to itself.

It may well be doubted, whether the covering of a bridge on any construction, with trusses or framed work to support them, for spans of more than 100 feet, presents more surface of obstruction to the winds, than is secured from its action by the inclosure. If not covered, all the timbers have half of their surface exposed to strong winds, in a manner similar to what would be the case if such bridge, with all its timbers, were immersed in a quick current of running water; it is evident that in both cases, more surface is exposed to the action of the moving fluid, than would be the case if covered sufficiently to keep out the weather. The reason of which is, because half of the exterior surface of the covering, &c. of a bridge is probably much less than half of the exterior surface of all the timber, plank, &c. of the uncovered bridge; the covering protects the interior timbers, &c. from the action of winds, and presents its own volume only, as one mass, to its force.

The great exposure to decay, from having the feet of the arches stand below the floor of the bridge, and bear or butt against the abutments and piers, thereby occasioning certain decay of their timber, sooner or later, has, in some instances, been obviated by placing the feet of the arches into the tie-string pieces. This certainly does away with the danger of decay, but another greater difficulty succeeds, viz. that in arches of any considerable span, the arch timbers must be, in a segment of a

circle, so flat as to be wholly incapable of bearing so great a weight as that of the bridge itself, and the travel over it, which it would be required to sustain also.

It is a well established fact, ascertained by practical experience, that a flat segment, or, which is the same, a small portion of the circumference of a circle or other curve, when applied to the arch of a bridge, executed in wood, becomes so much exposed to the compression of its wood, by a thrust-strain, as to be wholly inadequate to the purpose. The reason of which is founded in the plain mathematical principle, that as any curved arch of a given span, loaded with a given weight, approaches, by its low altitude, to a horizontal line, its exposure to the compression of its materials, in a thrust manner of strain, increases to an almost incredible degree; so much so, that the wood, which does not increase in its density, or power to resist compression, but remains stationary in this respect, becomes too weak and entirely insufficient, until at last, on a near approach to the horizontal line, even one tenth of its own weight could not be sustained.

In wide spans, to raise the arch so as to give it its adequate power to support a bridge, would present so large a volume to the wind, and that too with such great leverage, as might, indeed, create reasonable fears for the safety of such a construction.

The opinions and descriptions of several eminent engineers in England, in their late publications on bridges and railroads, are here introduced.

David Stevenson, in his sketch of the Civil Engineering of North America; London, John Weale, Architectural Library, 59 High Holborn, 1838; has the following account of this mode. He however, did not see but a small number of those that are well constructed.

"Plate 9th is a drawing of 'Town's Patent Lattice Bridge,' which is much employed on the American railways. This construction is sometimes used for bridges of so large a span as 220 feet, and it exerts no lateral thrust, tending to overturn the piers on which it rests. A small quantity of materials, of very small scantling, arranged in the manner shown in the plates, possesses a great degree of strength and rigidity.

"For this drawing, I am indebted to Mr. Moncure Robinson, of Philadelphia, who is constructing many large bridges on this principle, on the Philadelphia and Reading Railway, several of which I examined, both in their finished and unfinished state.

"If the bridge is of greater extent than can be included in one span, it is simply rested on a thin pier, in the manner shown in the elevation, without any other support. A covering of light boarding, extending from the level of the road-way to the bottom of the ribs, is spiked on the outside of the lattice-work to preserve the timber.

"The largest lattice-bridge which I met with, was constructed by Mr. Robinson, on the Philadelphia and Reading Railroad. It measures 1,100 feet in length. The lattice-frames, of which it is formed, extend throughout the whole distance, between the two abutments, without a break, and are supported on ten stone piers, in the manner shown in the plates.

"On the New York and Harlem Railway, there is a lattice-bridge 736 feet in length, supported in the same manner, on four stone piers."

Since the above, there have been others finished, of much greater extent and goodness, both under the direction of Moncure Robinson, Esq. and others. That at Richmond, Va., is so remarkable for its magnitude and grandeur of effect, from the very bold and rich landscape of that fine city, that its description may well be here introduced, for it will convey both practical information and rational entertainment.*

The Railroad Bridge across James River.

What is there yet to be done upon the face of the earth, that cannot be effected by the powers of the human mind, connected with the ingenuity of the human hand? The great elementary principles of nature have long ago been mastered by the skill of

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* The following description of a bridge, constructed on the improvement of Ithiel Town, as patented in 1835, it is fully believed will serve to show, not only the confidence of one of the most eminent and experienced engineers of the United States, in the superior durability, economy, and strength of principle, as lately improved by Mr. Town, but also the confidence which the public now feel in this mode of construction, from this and many other railroad bridges now in use or being erected. Among which is one on the Harlem Railroad, near New York; four over the North and Mohawk rivers, near Troy; one executed in a most splendid manner, over the Schuylkill, near Philadelphia, for the Baltimore Railroad; two on the railroad from Petersburg to Raleigh, N. C.; one at Tuscaloosa, Ala.; one at Circleville, Ohio, &c. Reference to Mr. Town's advertisement in the National Intelligencer, of August 5th, 11th, &c., and in the New York Weekly Express, of the 4th of August, 1839, for terms and other particulars.—*New Haven Daily Herald, September 19th*, 1838.

man, and rendered subservient to his wants and happiness. The bowels of the earth and the fathomless ocean, have alike been made to pour forth their treasures at his bidding. He has navigated the sea and the air, and made the inanimate objects of nature perform the labor that would have otherwise devolved upon his own hands. He has even, by his inventions, contemned the drudgery of personal locomotion, and caused himself to be carried, from point to point, upon the face of the earth and the waters, by inanimate agents, "with the rapidity of the wind;" while he luxuriously reclining, as though quiescent, drinks in new draughts of knowledge from the great fountain of the press, at once the offspring and parent of his intelligence. He is indeed, "lord of creation;" and all nature, as though daily more sensible of the conquest, is progressively making less and less resistance to his dominion.

The great bridge across James river, at Richmond, for the accommodation of the Richmond and Petersburg Railroad, may justly be considered as one of the greatest works of its kind in this country, or perhaps in the world. There are longer bridges of less altitude, and higher bridges of shorter span; but when the altitude and length of span of this bridge are taken collectively, there is, perhaps, not its equal in the world.

The location of the bridge is across the falls of the James river, a few hundred yards above tide water, where the velocity of the current is exceedingly great. It is constructed of substantial lattices, upon lofty granite piers, with a floor upon the summit of the lattice frame. The stoutness of the flooring corresponds with the general strength of the design, and it is rendered water and fire proof, by a strong coat of pitch and sand. The entire length of the span of the bridge is 2,900 feet, and the span between the piers 160 feet. The entire width of the floor is 22½ feet, (wide enough for a double railroad track,) being wider than, and projecting over the lattice-frame, 2½ feet on each side; the framework is, therefore, 17½ feet wide, on the top of the piers. The piers are 18 in number, founded in the rapids, upon the solid bed of granite rock that lies beneath. The elevation of the piers above common water is 40 feet, and their dimensions 4 by 18 feet at the top, increasing one foot in width and one foot in thickness, for every 12 feet in the descending scale. The masonry consists of regular courses of heavy stone, hewn to a joint on

their fitting surfaces; but on the showing faces of each pier, the stone is rough as it came from the quarry.

The whole structure was designed with a view to as much economy as was thought consistent with a just regard to strength and durability. Its execution was commenced in December, 1836, and the work was finally completed on the 5th of September, 1838, at an expense of about $110,000. I doubt whether any bridge of the same gigantic dimensions and substantial character, composed of such choice materials and rare workmanship, has ever been constructed at a smaller expense. This work was projected by Moncure Robinson, Esq., chief engineer, and executed under the direction of himself and his principal assistant. The work itself stands like a mighty Colossus, bestriding the ancient Powhatan, destined to hand down to posterity both itself and its authors; and those piers of imperishable granite will remain as proud monuments, to remote generations of the present State of Virginia, and her sons, as connected with the sciences and the mechanic arts.

This improvement possesses the very important advantage of exerting no *lateral strain* upon piers or abutments; an advantage that cannot be too highly appreciated in aqueduct bridges; to completely avoid this lateral pressure, becomes immensely important in their *cost* and *safety*. This mode of construction is perfectly suited to the purposes of aqueduct bridges, as well as all others, especially for railroads; it being continued horizontally, and admitting, in the principle and practical execution, of any degree of strength that may be required, for any span which is practicable under any circumstances; it also presents the advantage of having the trunk or canal so suspended, as to preclude all possibility of self-destruction, by the leakage coming in contact with any of the important timbers, besides rendering other facilities, of the greatest importance in the mechanical execution, as connected with the top and side bracing. When the great facility and ease with which this kind of bridge is covered, is considered, in connection with other advantages, its adoption for all purposes of bridges, aqueduct bridges, railroad bridges, canal bridges, &c., is beyond all question desirable, as the strongest, most durable, and by far the cheapest mode of construction, and to keep in repair.

It may be stated *most truly*, that if most bridges were built with spans of 200 feet or over, there would be a much less num-

ber of different principles in bridge building used, than at present; for although a very indifferent principle, or execution of a principle, or even *both*, will answer a considerable purpose for a time, for bridges of 75 to 120 feet spans, yet, it is always apparent *very soon*, and beyond *all question*, whether the principle or execution of bridges having spans of 200 feet or more, are sufficient or insufficient; here is no room for doubt—no disguise; the principle and practice, *both*, must be good, or the defect will soon exhibit itself in some shape not to be misunderstood. The reason of this difference between large and small spans is evident—it is for the same reason that a model of some modes of building bridges may have considerable strength, and appear to *many* to be good, yet when executed *full size*, will either fall down when the stages are removed, or soon thereafter. Perhaps the most obvious explanation of the reason of this fact may be thus explained, viz. suppose a piece of pine wood, half an inch square and 15 feet long, supported at the two ends, and resting in a horizontal position; it is easy to perceive that it would have strength to sustain its own weight, and probably something more. Conceive this to be an exact model of another stick of the same kind, the dimensions of which should be every way increased in a twenty fold ratio, viz. 300 feet long, and 10 inches square; let this stick be supported at the ends, as the model of it was, and what would be the result? *Nay*, cut it into three pieces of 100 feet each, and would they, if supported in the same manner, bear their own weight? Most certainly not.

Thus, then, the idea or belief that models are good representations of the strength of bridges when built, is erroneous in the extreme, and leads to sure disappointment and the destruction of property. Models of bridges only show the *relative* strength, or merit of different modes or principles; this they show pretty *accurately*, when made to the same scale, to the same width of spans, of the same materials, and in all other respects similar. Perhaps no one error has done more mischief, in the hands of unscientific and ignorant mechanics, than the misunderstanding of the nature and real use of models, in illustrating the strength and goodness of bridges. Millions have been sacrificed in this country, either in this manner, or in a way so similar as not to need a nicer distinction.

Here follow some formulæ, for the investigation of models, in accordance with the best writers on the subject:

From an experiment, made to ascertain the firmness of the model of a bridge, or of an edifice, certain precautions are necessary, before we can infer the firmness of the structure itself.

1. If the side of a model be to the corresponding side of the structure, as 1 to n, the stress which tends to *draw* asunder, or to *break transversely* the parts, increases from the smaller to the greater scale, as 1 to n^3; while the resistance of those ruptures increases only as 1 to n^2. The structure, therefore, will have so much less firmness than the model, as n is greater. If w be the greatest weight which one of the beams of the model can bear, and w the weight or stress which it actually sustains, then the limit of n will be $n = \frac{\mathrm{w}}{w}$.

2. The side of the model being to the corresponding side of the structure as 1 to n, the stress which tends to crush the parts by *compression*, increases from the smaller to the greater scale, as 1 to n^3, while the resistance increases only in the ratio of 1 to n. Hence, if w were the greatest load which a modular wall or column could carry, and w the weight with which it is actually loaded; then the greatest limit of increased dimensions would be found from the expression $n = \sqrt{\frac{\mathrm{w}}{w}}$. If, retaining the length or height $n\,h$, and the breadth $n\,b$, we wished to give to the solid such a thickness $x\,t$, as that it should not break in consequence of its increased dimensions, we should have $x = n^2 \sqrt{\frac{w}{\mathrm{w}}}$. In the case of a pilaster with a square base, or of a cylindrical column, if the dimension of the model were d, and of the largest pillar, which should not crush with its own weight when n times as high, $x\,d$, we should have $x = n \sqrt[3]{\frac{n^2\,w}{\mathrm{w}}}$. These theorems will often find their application in the profession of an architect or an engineer.

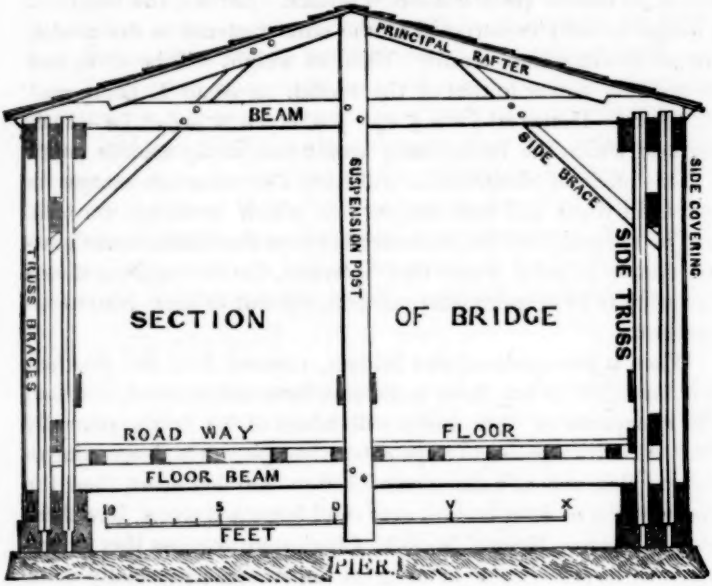
3. Suppose, for an example, it were required to ascertain the strength of a bridge on this improvement, from experiments made with a model. In this construction, the truss-work is carried across from pier to pier, so that the road-way entirely across, shall be in a horizontal plane, and all the parts shall retain their own respective magnitudes throughout the structure. Now, let l rep-

resent the horizontal length of the model, from interior to exterior of the two piers, w its weight, w the weight it will just sustain at its middle point B before it breaks. Let $n\ l$, the length of a bridge actually constructed of the same material as the model, and all its dimensions similar: then, its weight will be $n^3\ w$, and its resisting power to that of the model, as n^2 to 1, being $=n^2$ $(\mathrm{w}+\frac{1}{2}\ w.)$ Hence $n^2\ (\mathrm{w}+\frac{1}{2}\ w)-\frac{1}{2}\ n^3 w=n^2\mathrm{w}-\frac{1}{2}n^2\ (n-1)\,w$, the load which the bridge itself would bear at the middle point.

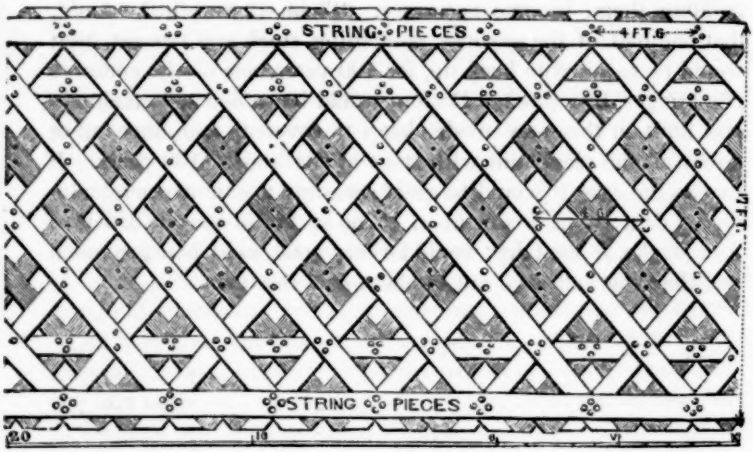
This mode of construction will have the same advantages in iron as in wood, and some in cast iron which wood has not, viz. that of reducing the braces in size between the joints, and of casting flanges to them where they intersect, thereby making it unnecessary to have more than one bolt and nut to each joint or intersection.

When it is considered that bridges, covered from the weather, will last eight or ten times as long as those not covered, and that the cheapness of this mode will admit of its being generally adopted, with openings or spans between piers which are composed of piles, and at a distance of 150 to 200 feet apart, then the construction of long bridges over mud bottomed rivers, like those at Washington, Boston, Norfolk, Charleston, &c., on this principle, will be perceived to be of great importance; especially as the common mode of piling is so exposed to freshets, uncommon tides, drift-wood, and ice, as not to insure safety or economy in covering them, and consequently continual repairs, and often rebuilding them, become necessary. There is very little doubt, that one half of the expense, computing stock and interest, that would be required to keep up, for 100 years, one of the common pile bridges, like those at Boston, would be sufficient to maintain one built in this new mode, keep it covered, and have all or nearly all the piers built with stone at the end of 100 years. If this be the case, it would be great economy to commence rebuilding by degrees, in this manner. The saving in the one article of floor planks, if kept dry, would be very great, as by being so much wet they rot, and wear out in about half the time.

No. 1. *A section of a bridge, with the roof, suspension posts, and all the parts, upon the pier, with a scale of feet.*



No. 2. *The side elevation of a truss, to the same scale. The height of a truss may be greater or less, by any number of half diamonds, or by a change of the angle of the truss-braces.*



Description of the Plates, with Definitions of technical terms, &c.

Numbers 1, 2, and 3 exhibit all the parts of a bridge on the last improvement, with suspension posts, &c., suited to a span of 170 to 220 feet, according to the size and number of its parts, which may be so varied as to suit the width of span required.

Definitions, Explanations and General Remarks.—1st. A truss is that combination (No. 2) of materials, which, with one or more other similar ones, constitute the whole vertical support of the bridge. They are placed in a vertical position on the piers, and are kept so by the addition of bottom beams, top beams, and horizontal and side braces, as shown in No. 1.

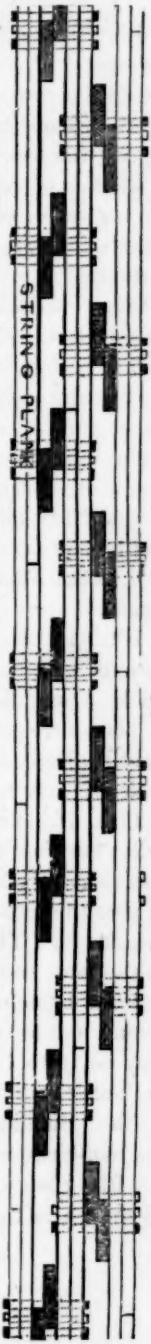
These few parts may be termed the skeleton of the bridge, and constitute the whole strength and support of the superstructure; to which a floor is added, for the conveyance of travel, produce, goods, &c., and generally a roof and side covering, to save the skeleton and floor from that decay which is incident to its exposure to the weather.

2d. Truss-braces, or diagonal braces, are those crossing each other, and forming the truss into diamonds. There are two series or sets of such truss-braces, separated by middle string-pieces, six or seven inches thick. (See figs. 1 and 2.) Each series of truss-braces may be termed a lattice; hence it is, by some, termed the double lattice bridge. The diamond-truss bridge, double diamond-truss, or double diamond bridge, would be more appropriate and better understood.

3d. String-pieces are all those horizontal parts of a truss, at top and bottom, or intermediate, which run the whole length, and are secured to the truss-braces by three or four tree-nails, at each intersection of them, over which the string-pieces pass.

4th. Intermediate string-pieces are those which pass over the lines of intersections of the truss-braces, between the extreme top and bottom string-pieces. Middle ones are here added, and the others may be added when more strength is required.

5th. Centre, or middle string-pieces, are all those which run between the two series of truss-braces, whether at top, at bottom, or intermediate; intermediate middle ones only, are here represented.



No. 3. The top or bottom view of a truss, showing the edges of the string-pieces, tree-nails, and ends of the truss-braces, to a double scale.

6th. String-plank are those pieces of which all the string-pieces are composed, and are half the thickness of the string-pieces, and are, in this case, 27 feet long. They break joints in their centres.

7th. Floor-beams are those which rest upon the trusses, and support the flooring of the bridge. The size of them should be in suitable proportion to the distance between their bearings upon the trusses, or suspension-posts and trusses, when the former are introduced; great depth in proportion to their thickness is important.

8th. Suspension-posts (see No. 1) are pieces 12 or 14 inches by 4 or 5 inches, firmly secured by tree-nails, locking, &c. to the top and bottom beams, and to each pair of principal rafters. They are introduced instead of a middle truss, for the support of the floor beams of a covered bridge, when the floor is on the bottom beams, and when the width of the bridge is so great that floor beams of sufficient strength cannot be procured.

9th. Floor-joists are pieces running lengthways of the bridge, and resting upon the top of the floor beams. They should be $4\frac{1}{2}$ to 6 inches square, according to the distance apart of the floor beams.

10th. Floor-planks are the pieces resting on the floor-joists, of various widths, from 6 to 12 inches, and from $2\frac{1}{2}$ to 4 inches thick, as may be required. In some instances, two thicknesses of planks are preferred; in which case, they cross each other at right angles or obliquely, and may be of less thickness, or such as their use may require.

11th. Horizontal braces at the top are either framed in diagonally, between the top beams, or consist of long planks of suitable dimensions, spiked and tree-nailed to the top of the beams, so as to give the most secure support, to keep the trusses in a straight line at top. This is a very important support, and should be done in the most secure manner, in every respect.

12th. Principal rafters are those which stand upon the top beams, and are thoroughly secured to them at their feet. They may be 10 to 12 inches deep, and 4 to 5 inches thick, according to their length.

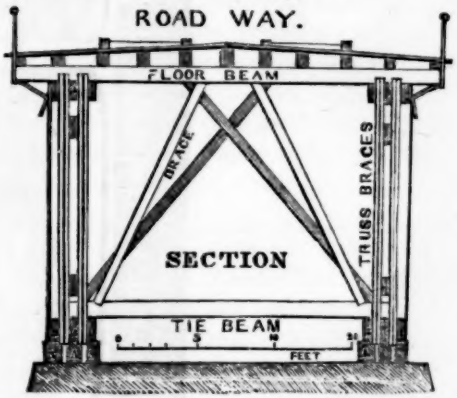
13th. Small rafters are those between the principal ones, to nail the roof-boarding to, for the purpose of shingling.

14th. Floor-braces, or bottom-braces, are pieces about $4\frac{1}{2}$ by $6\frac{1}{2}$ inches, as their length may require, framed in and keyed, be-

tween the bottom beams, to keep the bottom part of the bridge secure against any motion or vibration sideways, by wind, travel, or transportation.

15th. Side-braces (see No. 1) are pieces about $4\frac{1}{2}$ by $5\frac{1}{2}$ inches, connected with the side-truss, the top-beam, and the principal rafters, for the purpose of preventing the side-trusses from leaning, or inclining up or down stream. In the section No. 4, the side-braces are differently secured, and may cross each other or not, as shown in the section. By crossing, greater strength is obtained.

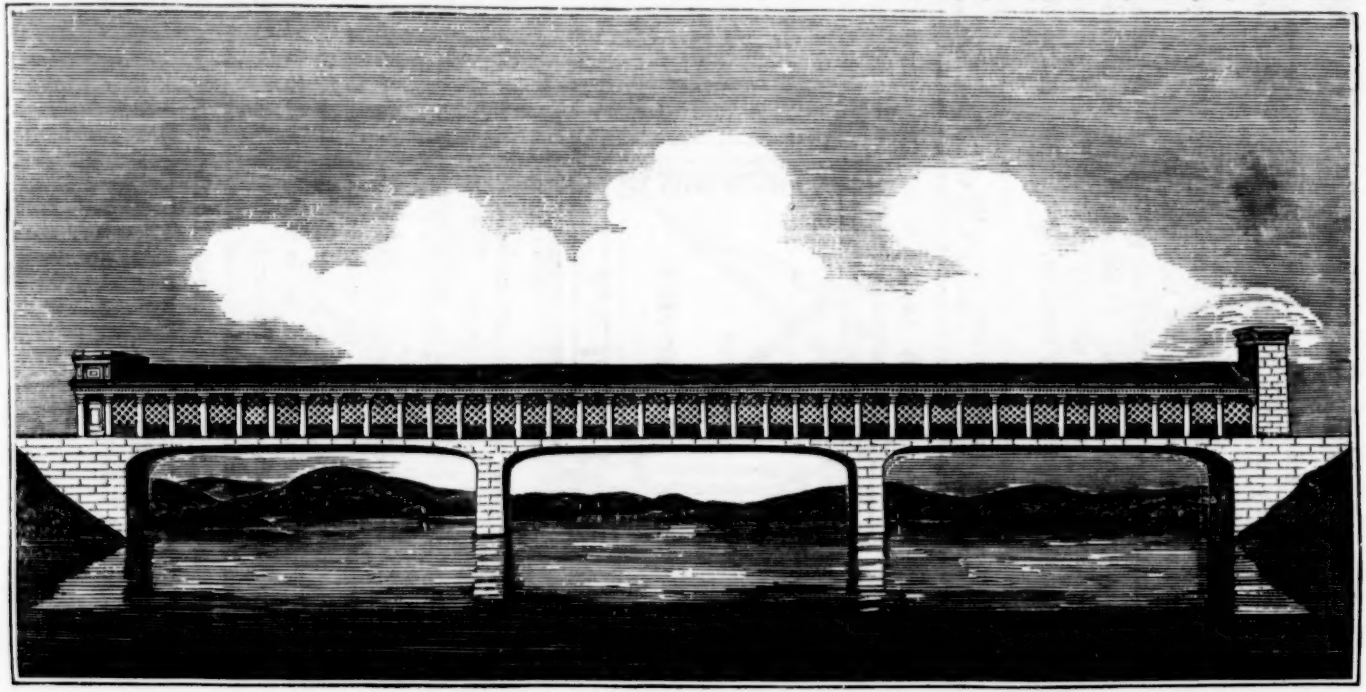
No. 4. A section of a bridge, with the floor, side railing, &c. on the top of the trusses. The floor may easily be made to turn off the water, and with side boarding, would be effectually secured from the weather. A scale is annexed.



16th. Side-walks are sometimes made for foot travel, and may be in the inside or on the outside. They are parted off by a railing 3 or 4 feet high, and if on the outside, may be made very ornamental, as seen in No. 5.

17th. Tree-nails of two inches diameter, made of white oak or other hard wood, are used for securing the truss-braces and string-pieces together, as seen in Nos. 2 and 3. They should be exactly fitted to the augers used, so as when seasoned to drive tight, and make solid work. Tree-nails may be made different ways, but the best and most economical is, to saw them out square from plank, with a circular saw, and then turn them with a small lathe, attached to some water or other machinery. They should be unseasoned, to be easily made, but must afterwards be well seasoned before driven into the work; they will season

No. 5. A perspective view of a roofed bridge, with side-walks on the outside, protected by colonnades and railings, finished in a very rich style of decoration.



quick, or may be kiln-dried. Tallow, or oil, &c. may be rubbed upon them, to make them drive more easily, if necessary.

18th. Abutments are the two supports of a bridge or aqueduct, at the ends, and are erected against and connected with the banks, on each side of the stream or ravine. They may be constructed in various ways, the same as the piers, if any, with which they are connected. The abutment for a bridge, on this improvement, requires no other strength or solidity, than a pier of equal exposure, there being no lateral or horizontal pressure, to affect either the abutments or piers, and therefore a perpendicular support only is required, sufficient to bear up the weight of the bridge, and that which may pass over it. One or more draws, for the passage of shipping, &c., may consequently be any where placed or constructed, without producing the least injury to this kind of bridge, as its strength and safety do not depend, in the least, on being connected throughout; except very partially, as respects the action of severe gales of wind, in which case, a structure in one entire connected mass, is of course somewhat less liable to be acted upon.

ART. XI.—*Description of an Economical Apparatus for Solidifying Carbonic Acid, recently constructed at the Wesleyan University, Middletown, Conn.;* by JOHN JOHNSTON, A. M., Professor of Natural Science.

THE solidification of carbonic acid has of late excited considerable interest both in Europe and in this country; but the cost of the necessary apparatus has been considerable, and many probably have on this account, merely, been prevented from making any attempt to repeat the experiment. Most of our public literary institutions, in which alone in this country such apparatus is ever used, are obliged to study economy, and they are therefore often liable to be prevented from availing themselves of the benefits of new discoveries like the present, merely on account of the expense of apparatus.

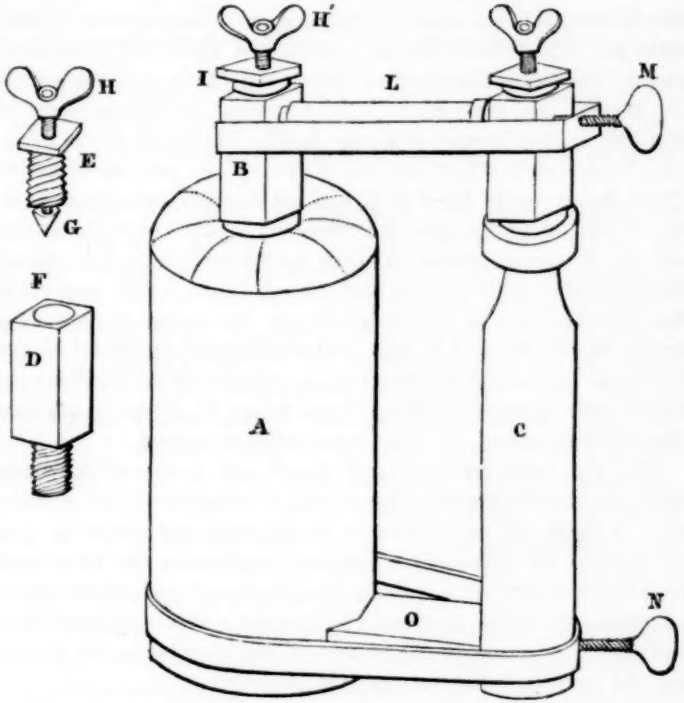
It is therefore thought a description of an economical apparatus for solidifying carbonic acid may be acceptable to the public, though we do not pretend to offer any thing new on the general subject.

The generator A is made of a common mercury flask, several of which I have tested and find sufficiently strong. They may be purchased in New York for a dollar a piece, or even less. The aperture at the neck may be a little enlarged, so as to make it an inch or an inch and a quarter in diameter, and the thread of the screw re-cut. A plug of cast-steel B is made of a bar two inches in diameter, and turned with a wide and smooth shoulder, so as to fit accurately upon a collar of block-tin when screwed into its place, as represented in the figure. This collar should be soldered to the iron; which is easily accomplished by filing the iron bright and tinning it in the ordinary manner, and then melting the block-tin and pouring it on, having first screwed a cork into the aperture and formed a wall of putty or clay at a sufficient distance around it. The shoulder of the plug is readily made to fit the collar accurately by screwing it a few times into its place, and then removing with a coarse file the parts of the collar upon which it touches. In this manner an accurate joint may be made without the use of a lathe; and if the plug does not correspond precisely with the axis of the flask it is just as well.

The faucets or stop-cocks are the most difficult part to construct, and occasion full half the expense. These in our apparatus are supposed to be essentially the same as are used by others for this purpose, but it may not be amiss to insert a description, since none has to my knowledge been given. There is this peculiarity about ours, however; they are inserted in the cast-steel plugs, which indeed make a part of them. D is designed to represent the plug removed from the generator; at the upper end of it a hole F one inch in diameter is drilled about an inch deep, terminating in a hollow cone into which the point G is accurately ground. A small hole extends quite through the plug. Around the aperture F a collar of block-tin is fitted to receive the shoulder of the part E, as seen at I, and prevents any passage around the threads of the screw. Through the axis of the part E a hole three eighths of an inch in diameter is drilled, and receives the part G which is screwed in from below, the handle H being removed. The handle H should be afterwards riveted on.

Now suppose H E G to be inserted in its place in the cast-steel plug, as represented at B I, the plug itself being screwed into the generator. If H′ be screwed down, the aperture from the generator is firmly closed by the conical point G; and by giv-

ing H′ a single revolution in the opposite direction, the shoulder of G is brought firmly against the bottom of E, so that no escape is permitted directly upward, but only in a lateral direction through the brass tube L, which connects the generator with the receiver C. A washer of sheet lead should be placed around the shoulder of G, in order to secure a perfect metallic contact between it and the bottom of E.



The receiver C is made of the best boiler iron, which was strongly welded around a cylinder and a bottom also welded in. It is of the same height as the generator, which is about one foot, but only about two inches in diameter internally, and has a capacity of about one pint. This form enables it to resist much greater pressure than if it was of a larger diameter; and it is rather an advantage than otherwise to have it of the same length as the generator.

A cast-steel plug with stop-cock precisely similar to the one described, screws into the receiver, as the other does into the generator. The tube L screws into the plug which is inserted in the receiver, and the other end, turned to a conical point, fits accurately into a cavity in the plug B, and is held in its place by means of the stirrup screw M. Another stirrup screw N, and block of wood O, secures the receiver C in its place.

To use this apparatus the generator and receiver are separated, and the plug B being removed, two pounds of bicarbonate of soda, made into a paste with the same weight of water, are introduced into A, and twenty ounces* of strong sulphuric acid are poured into several lead vessels, made by soldering bottoms in pieces of lead tube a little shorter than the length internally of the generator, and of such a diameter that they will just pass the aperture. These being nearly filled with acid are dropped into the generator, which, after the plug B is inserted, is allowed to lie on one side for fifteen or twenty minutes, or a less time if it is several times rolled over to mix the acid with the soda. The receiver is then attached to it as seen in the figure, by means of the stirrup screws M and N; and if kept sufficiently cool by means of ice, the liquid carbonic acid formed in A will shortly be distilled over into C, the passage between them being of course previously opened by means of the stop-cocks before described.

The stop-cocks are now to be closed and the receiver, which now contains the liquid carbonic acid, separated from the generator. A small tin cup is then to be attached to the tube L, precisely as in Dr. Mitchell's apparatus,† to receive the jet of acid from the receiver. It is essential that the *liquid* acid should escape into this cup, which is effected by having a small tube pass from the steel plug nearly to the bottom of the receiver, or by inverting the receiver before opening the stop-cock.

The best method of testing the strength of the apparatus, is by means of a hydraulic press, but it can be done as effectually by permitting it to lie, when charged, exposed to the direct rays of the sun, and excluded from currents of air, till the temperature

* The quantity of acid required to saturate or neutralize the soda would be a little more than 24 oz., or 22 oz. only if the soda is in crystals, but something less than this should always be used.

† Journal of the Franklin Institute, Vol. xxii, p. 289, and Vol. xxxv, p. 346, of this Journal.

rises to 100° or 110° F. This should be done two or three times before running any risks by venturing to handle the apparatus while charged.

It has been our object to construct an apparatus for forming the solid acid merely, but the gauges for ascertaining the pressure, &c. might of course be added as in Dr. Mitchell's apparatus.

The above apparatus, including the expense of testing three times, cost us about nineteen dollars.

ART. XII.—*Observations made at Canton, China, on the Shooting Stars of the 10th and 11th of August*, 1839, *in a letter from* Rev. PETER PARKER, M. D. *of Canton, to* E. C. HERRICK.

"IN accordance with your request I have made observations for shooting stars on the evenings specified in your letter. On the 3d of August, 1839, a gentle South wind prevailed during the day. The evening was beautiful; but discovering only *two* meteors between 8 and 9 o'clock, I gave up the watch. Aug. 4. Cloudy. Wind N. At 3 P. M., came on a sudden and violent squall from S. S. E., which drove the cargo boats with their anchors against a six-knot tide. Several lives were lost in the river front of the factories. Aug. 5. Cloudy. Aug. 6. From 10*h.* to 10*h.* 30*m.* P. M. saw but *three* meteors. Aug. 7. Strong gale from S. E. Aug. 8 and 9. Storm continued. Aug. 10. Extremely pleasant during the day and evening, with a gentle breeze from the South. At 8*h.* P. M. *three* meteors fell simultaneously: at 8*h.* 5*m.* a fourth. At 8*h.* 10*m.* a very beautiful one from Cassiopeia to the S. It had the singular appearance of being propelled by three distinct successive forces, and moved in an irregular but graceful undulating course. At 8*h.* 30*m.*, another, similar to the last: at 8*h.* 45*m.*, one from α Serpentis to the S. Other duties then interrupted the observations. At 10 o'clock observations were commenced by two persons and continued about two hours, during which time the following meteors were seen by them.

10*h.*	P.M.	1	fr.	Cassiop. to S. E. very beautiful.	10*h.*	12*m.*	1	
	5*m.*	1	"	Zenith to N.		13	2	fr. Zenith to S.
	7	1	"	" " Ursa maj.		15	2	" " " "
	10	1	"	" " do. small.		22	1	" Cass. to Ursa Major, the train was very broad and visible for half a minute.
	11	1	"	" " do.				

10h. 24m. 1 Ursa Major to S.
29 2 towards W.
30 1 S. E. to S. large.
37 1 Cass. to Ursa Major.
38 1
39 1 S. to W.
" 1 N. to W.
42 1 Ursa Major to S.
45 1 " " " "
47 3 " " " W.
51 1 S. to S. W.
54 1 S.—vertical.
55 2 Cass. to S.
55½ 2 " " S. swift.

30 meteors.

11h. 3m. 2 in S. beautiful.
8 1 fr. Zen. to E.
9 1 S. vertical.
10 1 Zen. to S.
12 1
15 1 Ur. Maj. to W. large.
17 1 Ur. Maj. to S.
21 2 Cass. to S.

11h. 22m. 1 Cass. to W.
22 2 Cass. to S.
24 1 Cass. to S. E.
25 1 Cass. to E.
28 1 Cass. to S.
29 1 Cass. to S.
29 1 Zen. to S.
30 2 Cass. to W.
31 1 Cass. to W.
32 1 Cass. to S.
33 1 Cass. to W.
34 1 Cass. to W.
36 1 Cass. to S. W.
39 1 Cass. to W.
40 1 Zen. to S.
42 1 Zen. to S.
43 2 Cass. to W.
44 1 Zen. to N. W.
45 1 Zen. to N. E.
45 1 E. to W.
46 1 Cass. to W.

34

August 11th. The observations commenced at an early hour, and continued until 4*h*. 30*m*. A. M. of the 12th. Below is a list of the meteors observed and recorded.

8h. 15m. P. M. 4 meteors.
17 2 fr. Zen. to E.
20 1 Zen. to W.
25 1 Zen. to W.
26 1 Zen. to W.
30 1 Zen. to S.
35 2 Zen. to S.
40 1 Zen. to W.
45 1 Lyra to S.
50 1 Serpens to S.
51 1 Zen. to S.

16

9h. 1m. 1 N. to E.
10 1 S. to N.
11 1 E. to S.
11 1 Zen. to S.
12 1 W. to E.
13 1 Zen. to E.
14 1 Zen. to N.
18 1 S. to N.
19 1 Cass. to S. large.
26 1 S. to N.

9h. 29m. 2 Zen. to S.
31 1 E. to S.
32 1 Zen. to S.
41 1
42 1 S. to N.
44 1 Cass. to N.
47 1 Cass. to N.
47 1 Lyra to S.
49 1 S. to N.

20

10h. 3m. 1 Zen. to S.
5 2
8 1 Regulus to N. very fine.
12 1 Zen. to S. long trail.
13 4
14 2
20 1 Zen. to S.
23 1 N. to S.
25 2
27 2 E. to W.
29 1
30 1 N. to W.

10*h*.	31*m*.	1 Zen. to S.
	33	1 W. to E.
	34	1 Cass. to S.
	40	1 N. to S.
	42	1 Lyra to S.
	43	1 N. to E.
	44	3 N. to S.
	45	1 Cass. to S.
	56	1 N. to S.
	57	1 W. to S.
	59	1 Cass. to S.
		32
11*h*.	2*m*.	1 W. to E.
	4	1 Cass. to N.
	6	2 Cass. to N.
	9	2 Cass. to S.
	15	3 Cass. to S.
	16	1 E. to W.
	17	1 Cass. to S.
	18	1 S. to Cass.
	23	1 Cass. to S.
	25	1 Ursa m. to S.
	25	1 Cass. to S.
	26	2 Cass. to S.
	30	1 Cass. to S.
	31	1 Cass. to S.
	33	1 Cass. to N.
	33	1 Zen. to W.
	35	2 Cass. to S.
	36	1 Cass. to S.
	39	1 Cass. to N.
	40	1 Zen. to W.
	40	1 Ursa m. to S.
	43	1 Cass. to S.
	45	1 Cass. to W.
	46	2 Cass. to W.
	46	1 Cass. to S.
	49	1 Cass. to N.
	50	2 Cass. to N.
	51	1 Cass. to E.
	51	1 Cass. to W.
	58	1 Cass. to W.
	58	1 Cass. to S.
		39
12*h*. A.M.	0*h*.5*m*.	1 Cass. to S.
	6	1 Cass. to S.
	8	3 Cass. to E. and W.
	10	1 N. to S.
0*h*.	11*m*.	1 S. to N.
	12	2 Cass. to W.
	12	1 Cass. to S.
	13	1 S. to N.
	15	2 Zen. to S.
	16	1 Zen. to S.
	20	2 Zen. to S.
	29	1 Cass. to S.
	30	1 Cass. to S.
	31	2 Cass. to S. and W.
	33	1
	35	2 Cass. to S.
	36	1 Cass. to W.
	37	1 Cass. to S.
	40	1 Cass. to W.
	45	2 Cass. to S. and W.
	46	1 Cass. to W.
	46	4 Cass. to S.
	50	1 Zen. to N. very fine.
	51	1 E. to W.
	53	1 Cass. to S. W.
	54	1 Zen. to S.
	55	2 Cass. to S.
	56	2 Cass. to S. and W.
	57	2 Cass. to S. and W.
	58	2 Cass. to S. and W.
	59	1 Cass. to W. large.
		46
1*h*.	1*m*.	1 Zen. to N.
	4	1
	5	1 Cass. to W.
	6	1 Zen. to E.
	10	1 Cass. to E.
	11	1 Zen. to W.
	12	5
	13	2 Cass. to S.
	15	1 Cass. to W.
	16	1 Cass. to S. W.
	20	1 Cass. to W.
	25	1 Cass. to W.
	25	1 Cass. to S. E.
	26	3 Cass. to S. W.
	28	2 Cass. to S. W.
	28	2 Cass. to N.
	30	1 Cass. to S.
	30	1 Cass. to N.
	31	2 Cass. to N.
	31	1 Cass. to S.
	33	5
	35	1 Zen. to S.

1*h*.	36*m*.	4 Cass. to S.
	40	1 Cass. to N.
	40	1 Cass. to E.
	46 to 52	3 Cass. to N. W. 12
	55	3 Cass.
	57	5 Cass. one fine.
	58	2 Zen. to S. W.
		67
2*h*.	0*m*.	1 Cass. to N. W.
	0	1 Zen. to N. W.
	1	1 Cass. to N.
	1	1 Zen. to N. W.
	2	3 Zen. to N.
	3	3 Zen.
	5	1 Zen. to N.
	10	2 Cass. to W.
	11	1 Cass. to N.
	11	1 Cass. to S.
	14	1 Cass. to W.
	14	3 Cass. to N.
	15	6
	16	1
	20	6 Cass. to E.
	30	3 Cass. to S.
	35	6
	37	1 Cass. to S.
	38	1 Cass. to N.
	40	1 Cass. to S.
	40	1 Cass. to W.
	42	5 Cass. to S. W.
	45	2 Cass. to S.
	46	2 Cass. vertical.
	48	1 Cass. to S. W.
	48	1 Cass. to S.
	49	2 Cass. to N. E.
	52	1 Cass. to S.
	53	2 Cass.
	54	1 Cass. to E.
	54	1 Cass. to S. W.
	55	1 Cass. to N.
	55	1 Cass. to S.
	56	2 Zen. to S.
	57	3 Zen. to S. W.
		70
3*h*.	0*m*.	1 Zen. to S. W.
	1	1 Zen. to E.
3*h*.	4*m*.	4 Cass. to E.
	5	1 Zen. to E.
	6	3 Cass.
	7	2 Cass.
	10	3 Cass. to S. W.
	12	1 Cass. to S.
	15	1 Cass. to E.
	17	3 Cass. to E.
	20	1 Cass. to E.
	22	2
	24	3 Zen. to S.
	25	7 Cass. to S. W.
	27	3 Cass.
	30 to 35	22 course not taken.
	37	6
	40	4
	42	4
	46	4
	47	5
	50	2
	54	2
	55	5
	56	3
		93
4*h*.	0*m*.	8
	5	4
	15	10
	25	8
	30	1
		31

Aggregate.

Aug. 10th,	10*h*.	to 11*h*. P. M.	=30 meteors.
	11	to 12 "	=34
			64
Aug. 11th,	8*h*.	to 9*h*. P. M.	=16
	9	to 10 "	=20
	10	to 11 "	=32
	11	to 12 "	=39
	12	to 13 "	=46
	13	to 14 "	=67
	14	to 15 "	=70
	15	to 16 "	=93
	16	to 16½ "	=31
			414

"There can be no question that the meteors of the night of the 11th of August, (1839,) exceeded the usual number. They attracted the notice of Europeans and Chinese, whose attention had not been called to the subject. Several friends watched on the night of the 12th from 9 P. M. till 2 A. M. (13th) and saw only about half a dozen meteors. I have repeatedly looked out since the 11th, [up to the 28th, the last date of the letter,] and have seen but very few meteors.

"The most casual observer on the 10th and 11th could not fail to notice that the great majority of the meteors were from the constellation *Cassiopeia*. One of the three meteors seen at 1*h*. 55*m*. of the morning of the 12th, was exceedingly beautiful. Starting apparently from the neighborhood of this constellation, it resembled a broad stream of burning phosphorus, until it descended within about 25° of the horizon. There it exploded, exhibiting a beautiful brilliant light, resembling the combustion of *iodide of phosphorus*, but far exceeding any thing of the kind ever witnessed in our laboratories. A white phosphoric color characterized the majority.

"In watching these phenomena, a person might easily receive the impression that they resulted from some combustible material in our atmosphere, which gradually accumulated until it took fire. Although the meteors were occasionally scattered along at intervals of a minute, yet more frequently they appeared in clusters about every five minutes. The majority of those from the vicinity of Cassiopeia took a Southerly or South-westerly course, but still while this region was the common starting point, the directions of many seem to be determined by no obvious law. Surely the South wind on this occasion had no influence, unless by the 'rule of contrary.'

"I may here mention that on the evening of the 12th of August, (following the evenings of the meteors,) about sunset, the wind was squally from the South, and the clouds were of a peculiar auburn tinge, approaching to a whitish red. This continued for two or three hours, when the clouds passed away, and a pleasant day succeeded. The same was the case after the meteors seen here in November, 1838. The coincidence may be quite accidental and unimportant, but the facts are perhaps worth mentioning.

"You have probably seen, in the Canton papers, that on the 5th of December, 1838, we had a merry exhibition of meteors. Two observers counted *a hundred and sixty* in one hour from $8\frac{1}{2}$ to $9\frac{1}{2}$, P. M."*

[*Note.*— The observations above recorded, (which are perhaps the first ever systematically made at this epoch in that part of the globe,) serve to confirm the position, that about the 10th of August, for two or three millions of miles at least, the earth traverses a region abounding with small planetary or nebulous bodies, which, when rendered luminous by their rapid passage through our atmosphere, we call *shooting stars*. The observers seem not to have endeavored to determine very closely the point of the heavens from which the meteors appeared to diverge; they refer it to *Cassiopeia* or its vicinity, which cannot be far from that part of *Perseus* in which the observations made in this country fixed the radiant, (this Jour. Vol. xxxvii, p. 328.) Regarding the whole number of meteors visible at Canton at this time, we can make no definite estimate, since we are not informed whether the positions of the two observers were such as to secure the greatest possible amount. The time of the night at which the meteors were most numerous, appears to agree with our previous approximate determinations. E. C. H.]

New Haven, Feb. 5, 1840.

ART. XIII.—*Remarks chiefly on the Synonymy of several North American Plants of the Orchis Tribe; by* ASA GRAY, M. D.

THERE are comparatively very few representatives of the remarkable family of Orchidaceous plants in the United States. The Epiphytic forms, now the pride of conservatories, embracing many of the most bizarre as well as splendid productions of the vegetable kingdom, belong to tropical climes. Many species approach the southern borders of the United States, but only one (*Epidendrum Magnoliæ*) is found within its limits. Linnæus described only fourteen species of Epidendrum in the first edition of the Species Plantarum, (1753.) Now, perhaps fourteen hun-

* These meteoric observations, as well as many others made about that time, in this country and in England, may be found in this Journal, Vol. xxxv, p. 361, and Vol. xxxvi, p. 355.

dred epiphytic species may sometimes be seen growing in a single hot-house. The genus Orchis, as at present constituted, although belonging to temperate regions and to the northern hemisphere, is almost wholly confined to Europe, and is represented in North America by a single species. Excepting this, all our Linnæan and Willdenovian species belong to Habenaria, as characterized by Brown, and to Platanthera and Peristylus of Lindley. Having had occasion recently to examine the specimens upon which these and other species were founded, I was surprised to find very great confusion in the synonymy; some of our commonest species having, as it appears, been widely mistaken from the time of Linnæus to the present day. When we consider how limited an interchange of specimens took place between the earlier botanists, how seldom they were able to consult each other's herbaria, taking also into the account the brevity in the specific phrase enjoined by the Linnæan canon, and the absence of any method of distinguishing between authenticated synonyms and the more or less probable ones which an author might venture to adduce, we shall not wonder at the frequent occurrence of such mistakes.

Only four North American species of Orchis are described by Linnæus, viz. *O. ciliaris*, *O. flava*, *O. psycodes*, and *O. spectabilis*. The latter is still retained in that genus. Respecting the first, I have no remark to make, except that Linnæus's reference to Gronovius, *Fl. Virg.*, is to be excluded, as it relates to *O. blephariglottis*. To this last the *Platanthera holopetala* of Lindley is perhaps too closely allied, as I have seen apparently intermediate specimens from Canada, and also in the Newfoundland collection of Pylaie. Sprengel states the flowers of *O. ciliaris* to be red. The two remaining Linnæan species require more extended notice.

Orchis flava, *Linn.* has remained an uncertain species quite down to the present time, no succeeding author having identified it. Pursh, indeed, remarks that he has seen the specimen in the herbarium of Gronovius; but he failed to recognize it as the same with another species described in his work, viz. his *O. fuscescens*. Nuttall has taken for it a very different species, (apparently his own *O. integra*;) in which he is followed by Elliott; who states, however, that the plant differs much from the original description of Gronovius. Having examined the herbarium of Clayton and Gronovius's *Fl. Virg.*, through the kind permission

of Mr. Brown and Mr. Bennett, I may state that a minute examination of the specimen on which this species is founded, proves it to be identical with the well known *Habenaria herbiola.* It is a somewhat loosely flowered form, with the stem rather naked above, exactly similar to those we often receive from the Southern States, as well as from Pennsylvania. The description of Clayton is so far correct, that it is probable the pale or greenish-yellow flowers alone have prevented all succeeding botanists from suspecting it to be the Linnæan plant. The specific name is certainly not happily chosen for a plant of which Clayton observes, "floribus obsolete luteis," but it must nevertheless be retained. The remarkable tooth or process on the upper side of the lip near the base, by which the plant is so well distinguished, is also unnoticed. I find the same species among the plants of Pursh, in Mr. Lambert's herbarium, under the name of *O. fuscescens.* This last species was established upon a figure and description of Gmelin's *Flora Sibirica,* which accord so well with the American plant, that, in the absence of specimens, I am unable to pronounce them distinct. The lip has the same lateral teeth, but, instead of the projecting process, Gmelin describes the posterior portion as "in cymbam fere excavata." The inspection of Willdenow's herbarium enables me to add as a synonym the *O. virescens* of that author; of whose character: "cornu obtusum scrotiforme brevissimum," it should be remarked that it is totally at variance with his own solitary specimen received from Muhlenberg, under this name. The latter, in his unpublished *Flora Lancastriensis,* thus describes the lip and spur:—"Labio nectarii oblongo emarginato indiviso et subtrilobo, vel basi utrinque dentato; cornu setaceum germine brevius, acutum." The synonymy of this species, so far as already ascertained, may stand as follows.

HABENARIA (PLATANTHERA) FLAVA.

Orchis flava, *Linn.! spec. ed.* 1. *p.* 942, *et ed.* 2., excl. syn. *Moris. hist.*, non *Nutt.*

Orchis radice palmata; floribus obsolete luteis, &c. &c. *Clayt.! no.* 639.

Orchis radicibus palmatis: nectarii labio trifido, integerrimo, &c. *Gronov.! fl. Virg. ed.* 2. *p.* 137.

Orchis virescens, *Muhl. fl. Lancast. ined., et in Willd.! spec.* 4. *p.* 37. (descr. pess.)

Orchis fuscescens, *Pursh! fl.* 2. *p.* 587; *Ell. sk.* 2. *p.* 487, vix *Gmel.*

Orchis herbiola, *Pursh, l. c.* (quoad syn.)

Orchis bidentata, *Ell.! sk.* 2. *p.* 488.

Habenaria herbiola, *R. Br.! in hort. Kew.* (*ed.* 2.) 5. *p.* 193, *et auct. omn.*

Habenaria virescens, *Spreng. syst.* 3. *p.* 688. (quoad syn.)

Habenaria fuscescens, *Torr. compan.*

Platanthera herbiola, *Lindl.! gen. et spec. Orchid.*

HABENARIA (PLATANTHERA) INTEGRA.

Orchis integra, *Nutt. gen.* 2. *p.* 188.

Orchis flava, *Nutt. l. c.*, non *Linn.*

Orchis flava? *Ell. sk.* 2. *p.* 485.

Habenaria integra, *Spreng. syst.* 3. *p.* 689; *Beck, bot. p.* 348.

Habenaria Elliottii, *Beck! l. c.*

This last species is very nearly allied to *H.* (*Platanth.*) *cristata*, but is readily distinguished by its subulate spur, entire petals, and nearly entire, crenate, or somewhat sinuately toothed labellum. Its geographical range is from New Jersey to Florida and Louisiana.

ORCHIS PSYCODES, *Linn.*—So great is the confusion of the synonymy, and so extensive the series of mistakes in regard to this species, that it becomes at first sight questionable whether the Linnæan name should not be altogether dropped. But as the description of Linnæus is perfectly applicable to the species he had in view, and to no other, we are not at liberty to pass by the original name; still less to apply it to a plant subsequently mistaken for this species. The *O. psycodes* is described from a plant collected in Canada, by Kalm, which is still preserved in the Linnæan herbarium. This plant I find to be, not the *Orchis lacera* of Michaux, as is generally supposed, but the *Orchis fimbriata* of Aiton and succeeding authors. The synonym of "*Orchis floribus aureis*," &c. of Gronovius, must be excluded, as it relates to *Orchis cristata* of Willdenow. The Gronovian plant, however, does not exist in the herbarium of Linnæus, neither does the character and description appear to have been at all derived from it. On the authority of the herbarium of Willdenow, and also from the manuscript detailed descriptions of Muhlenberg, I have ascertained that both the *Orchis incisa* and the *Or-*

chis fissa of these authors, are identical with the original *O. psycodes* of Linnæus; that is, are the ordinary smaller-flowered forms of *Orchis fimbriata.* Muhlenberg says of his *O. fissa*, that the flowers are very small; as indeed they are in the specimen sent to Willdenow, when compared with his *O. fimbriata*, (which is the *O. grandiflora* of Bigelow,) or with *O. fissa* of succeeding authors. *Orchis psycodes* of Willdenow, as to the plant in his herbarium, is *O. lacera* of Michaux. The synonymy of these species will therefore assume the following form.

Habenaria (Platanthera) psycodes.

Orchis psycodes, *Linn.! spec.* 2. *p.* 493, excl. syn. *Gronov.*, non *Willd.*

Orchis fimbriata, *Ait.! hort. Kew.* (*ed.* 1.) 3. *p.* 297, *et auct.*

Orchis incisa, *Muhl.! fl. Lancast. ined., et in Willd.! spec.* 4. *p.* 40, non *Pursh*, nec *Nutt.*

Orchis fissa, *Muhl.! l. c. et in Willd.! l. c.* non *Pursh*, nec *auct. seq.*

Habenaria fimbriata, *R. Br.! in hort. Kew.* (*ed.* 2.) 5. *p.* 193, *et auct.*

Habenaria incisa, *Spreng. syst.* 3. *p.* 692. (quoad syn.)

Habenaria fissa, *Spreng. l. c.* (quoad syn.,) non *R. Br.*

Platanthera fimbriata, *Lindl. ! gen. et spec. Orchid.*

β. grandiflora: labelli segmentis (lateralibus præcipue) capillaceo-fimbriatis, floribus majoribus.

Orchis fimbriata, *Willd. ! l. c.*

Orchis grandiflora, *Bigel. ! fl. Bost. ed.* 2. *p.* 321.

Habenaria grandiflora, *Torr. ! compan.; Beck, bot. p.* 349; *Darlingt. fl. Cest. ed.* 2. *p.* 509.

Habenaria (Platanthera) peramœna.

Orchis palmata peramœna, Caryophylli montani floribus, margine fimbriatis, ex Virginia. *Pluk. mant. p.* 141, *t.* 434, *f.* 5.

Orchis fissa, *Pursh ! fl.* 2. *p.* 588, non *Willd.*

Orchis incisa, *Pursh, l. c.; Nutt. gen.* 2. *p.* 189, non *Willd.*

Habenaria fissa, *R. Br.! in herb. Banks*, non Orchis fissa, *Muhl. et Willd.*

Platanthera fissa, *Lindl. l. c.*

HABENARIA (PLATANTHERA) LACERA.

Orchis radice palmata: foliis lilii, &c. *Clayt.! no.* 644; *Gronov.! fl. Virg. p.* 137.

Orchis psycodes, *Muhl.! l. c.; Willd.! spec.* 4. *p.* 39, non *Linn.*

Orchis lacera, *Michx.! fl.* 2. *p.* 156; *Pursh, l. c.; Ell. l. c.*

Habenaria psycodes, *Torr.! compan.; Beck! l. c.*

Habenaria lacera, *R. Br.; Spreng. l. c.*

Platanthera psycodes, *Lindl. gen. et spec. Orchid.*

HABENARIA (PLATANTHERA) CRISTATA.

Orchis floribus aureis, spica habitiore congestis: bracteis longitudine floris: labio inferiore nectarii fimbriato capillaceo: seta germine breviore. *Clayt.! no.* 688; *Gronov.! fl. Virg. ed.* 1. *p.* 184.

Orchis cristata, *Michx.! fl.* 2. *p.* 156; *Willd.! spec.* 4. *p.* 9; *Pursh! l. c.*

O. psycodes, *Pursh, l. c.?* non *Linn.*, nec *Willd.*

Habenaria cristata, *R. Br.! in hort. Kew.* (*ed.* 2.) 5. *p.* 194, *et auct.*

Habenaria psycodes, *Spreng. l. c.?* (ex colore florum.)

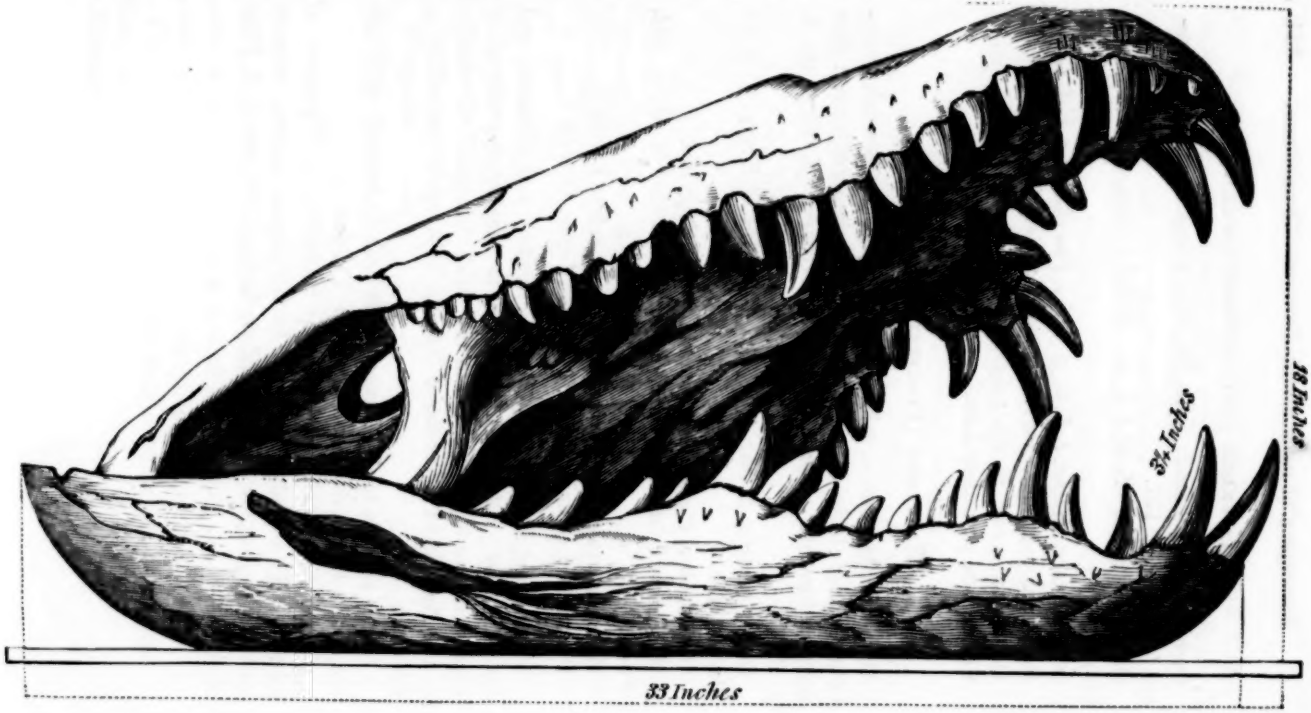
Platanthera cristata, *Lindl.! gen. and spec. Orchid.*

Respecting *Habenaria* (*Plat.*) *orbiculata* and *Hookeri*, and also *H.* (*Plat.*) *dilatata*, I have only to remark, that the view suggested several years since, in the third volume of the Annals of the New York Lyceum of Natural History, is proved to be correct.

Orchis obsoleta of Willdenow (fide herb.!) is made up of the scape of a Corallorhiza and a leaf of Tipularia?

Orchis limodoroides of the same herbarium is *Tipularia* of Nuttall. To this also belongs "Orchis floribus sparsis, nectario pedunculum superante, labio infimo lineari." *Gronov.! fl. Virg. p.* 137.

Head of an Alligator from Luconia—drawn from the original in the Museum of the Boston Society of Natural History.



ART. XIV.—*Account of the Capture and Death of a large Alligator.* Communicated for this Journal at the request of the Editors, by a gentleman concerned in the affair.

TO THE EDITORS.

THE interest you have manifested in the head of the alligator, deposited in the room of the Society of Natural History in this city, (see the annexed drawing,) and the request you have made that I would acquaint you with the circumstances of its capture, induce me to offer you the following sketch. Whatever imperfections may appear in it, must be attributed to the time that has passed since my residence at Manilla, near which place the alligator was killed.

The lake, from which flows the river on which Manilla is situated, is about twenty miles from that place. It is of irregular form, and from many points looks like three distinct bodies of water of about equal dimensions, caused by a long island nearly in the centre, and a wide tract of land parallel to and about eight miles from it. The latter, called Halahala, was a plantation which I occasionally visited, and was the property of a French gentleman, distinguished for his hospitality, and for a strength of character which had led him to establish himself successfully, alone and unaided, amidst a barbarous people, whose respect and love he had secured by his uniform courage, justice, and benevolence. A small part of the estate was cultivated by the hired Indians, whose huts formed a picturesque little village near the house of the proprietor, and the remainder, embracing a circuit of fifteen or twenty miles, gave every variety of natural beauty. A chain of high hills ran through the centre, whose summits were covered with grass so luxuriant as often to rise over the head of a man on horseback; and the forests on either side, extending in many places to the lake, were the growth of centuries. The axe had never thinned them, and they stood in their massive magnificence as nature had planted and reared them; some in fantastic forms, which gave them so much the appearance of works of art, as to be distinguished by the names of things they were supposed to resemble; some, vanquished by the creeping plant, which strangles in its close and deadly embrace what at first it clings to for support and protection, had struggled against

its folds till the destroyer and destroyed seemed one; and the giant tree, which, year after year, had been rocked by the earthquake and had borne bravely against the whirlwind, slowly yielding to its tenacious persecutor, stood at last lifeless within its green and living shroud.

Amidst the wonders of nature, animal life has its full share; and in the tangled recesses of the woods, where exuberant vegetation has given the earth a covering almost impenetrable to man, there live the deer, the boar, and that most desperate and dangerous enemy of the hunter, the wild buffalo, whose ferocity and contempt of danger is only equalled by his hatred of the human form. There is also the boa constrictor, sometimes seen of great size, who crushes in his folds and devours whatever first comes in his way; and then, gorged and inactive, is easily despatched. One with a large deer inside of him, was killed when I was there, but had been cut up by the natives for food, before we were aware of it. Since I left that country, I have been informed that one thirty-five feet long has been destroyed, after killing two Indians, who entered a cavern where he had retired, one of whom he swallowed, and the other was found dead beside him.

The deep, still inlets of the more retired parts of the lake, are the lurking places of the alligators; and one spot, remarkably situated, was their favorite resort. Nearly opposite to the point of Halahala, on the other shore, there issues from a mountain a stream of so high a temperature that the natives use it for cooking; and the bones of fish and fowls, scattered at its sides and in its bed, show how commonly it is availed of for that purpose. Rude baths are constructed near it, which are found very serviceable in chronic diseases, and are sometimes visited by invalids from Manilla. Near this place is an island, in the centre of which is a small, deep, black lake, surrrounded by hills, except at a narrow opening, which is low and marshy. The sides, as they slope to the margin, are thickly wooded, and the trees hang clustering over the banks, their dense foliage drooping to the water. Here reigns the stillness of death; not a breath of wind penetrates the close barrier, and there is sound and motion on the glassy surface, only when it is rippled by the alligators, who have made the place their own. At other times they float like logs, or stretched along the mingled masses of decayed wood and exposed roots, enjoy the coolness and shade of this gloomy solitude.

In the course of the year 1831, the proprietor of Halahala informed me that he frequently lost horses and cows on a remote part of his plantation, and that the natives assured him they were taken by an enormous alligator, who frequented one of the streams which run into the lake. Their descriptions were so highly wrought that they were attributed to the fondness for exaggeration, to which the inhabitants of that country are peculiarly addicted, and very little credit was given to their repeated relations.

All doubts as to the existence of the animal were at last dispelled by the destruction of an Indian, who attempted to ford the river on horseback, although entreated to desist by his companions, who crossed at a shallow place, higher up. He reached the centre of the stream, and was laughing at the others for their prudence, when the alligator came upon him. His teeth encountered the saddle, which he tore from the horse, while the rider tumbled on the other side into the water and made for the shore. The horse, too terrified to move, stood trembling where the attack was made. The alligator, disregarding him, pursued the man, who safely reached the bank, which he could easily have ascended, but rendered fool-hardy by his escape, he placed himself behind a tree, which had fallen partly into the water, and drawing his heavy knife, leaned over the tree, and on the approach of his enemy, struck him on the nose. The animal repeated his assault and the Indian his blows, until the former, exasperated at the resistance, rushed on the man, and seizing him by the middle of the body, which was at once enclosed and crushed in his capacious jaws, swam into the lake. His friends hastened to the rescue; but the alligator slowly left the shore, while the poor wretch, writhing and shrieking in his agony, with his knife uplifted in his clasped hands, seemed, as the others expressed it, "held out as a man would carry a torch." His sufferings were not long continued, for the monster sank to the bottom, and soon after reappearing alone on the surface, and calmly basking in the sun, gave to the horror-stricken spectators the fullest confirmation of the death and burial of their comrade.

A short time after this event, I made a visit to Halahala, and expressing a strong desire to capture or destroy the alligator, my host readily offered his assistance. The animal had been seen, a few days before, with his head and one of his fore feet resting on

the bank, and his eyes following the motion of some cows which were grazing near. Our informer likened his appearance to that of a cat watching a mouse, and in the attitude to spring upon his prey when it should come within his reach.

I would here mention, as a curious fact, that the domestic buffalo, which is almost continually in the water, and in the heats of mid-day remains for hours with only his nose above the surface, is never molested by the alligator. All other animals become his victims when they incautiously approach him, and their knowledge of the danger most usually prompts them to resort to shallow places to quench their thirst.

Hearing that the alligator had killed a horse, we proceeded to the place, about five miles from the house. It was a tranquil spot, and one of singular beauty, even in that land. The stream, which a few hundred feet from the lake narrowed to a brook, with its green banks fringed with the graceful bamboo, and the alternate glory of glade and forest, spreading far and wide, seemed fitted for other purposes than the familiar haunt of the huge creature that had appropriated it to himself. A few cane huts were situated a short distance from the river, and we procured from them what men they contained, who were ready to assist in freeing themselves from their dangerous neighbor. The terror which he had inspired, especially since the death of their companion, had hitherto prevented them from making an effort to get rid of him; but they gladly availed themselves of our preparations, and with the usual dependence of their character, were willing to do whatever example should dictate to them. Having reason to believe that the alligator was in the river, we commenced operations by sinking nets, upright, across its mouth, three deep, at intervals of several feet. The nets, which were of great strength, and intended for the capture of the wild buffalo, were fastened to trees on the banks, making a complete fence to the communication with the lake.

My companion and myself placed ourselves with our guns on either side of the stream, while the Indians, with long bamboos, felt for the animal. For some time he refused to be disturbed; and we began to fear that he was not within our limits, when a spiral motion of the water, under the spot where I was standing, led me to direct the natives to it; and the creature slowly moved on the bottom towards the nets, which he no sooner touched,

than he quietly turned back and proceeded up the stream. This movement was several times repeated, till, having no rest in the enclosure, he attempted to climb up the bank. On receiving a ball in the body, he uttered a growl like that of an angry dog, and plunging into the water, crossed to the other side, where he was received with a similar salutation, discharged directly into his mouth. Finding himself attacked on every side, he renewed his attempts to ascend the banks; but whatever part of him appeared was bored with bullets, and feeling that he was hunted, he forgot his own formidable means of attack, and sought only safety from the troubles which surrounded him.

A low spot, which separated the river from the lake, a little above the nets, was unguarded, and we feared that he would succeed in escaping over it. It was here necessary to stand firmly against him; and in several attempts which he made to cross it, we turned him back with spears, bamboos, or whatever first came to hand. He once seemed determined to force his way, and foaming with rage, rushed with open jaws, and gnashing his teeth, with a sound too ominous to be despised, appeared to have his full energies aroused, when his career was stopped by a large bamboo thrust violently into his mouth, which he ground to pieces, and the fingers of the holder were so paralyzed that for some minutes he was incapable of resuming his gun.

The natives had now become so excited as to forget all prudence, and the women and children of the little hamlet had come down to the shore to share in the general enthusiasm. They crowded to the opening, and were so unmindful of their danger that it was necessary to drive them back with some violence. Had the monster known his own strength, and dared to have used it, he would have gone over that spot with a force which no human power could have withstood, and would have crushed, or carried with him into the lake, about the whole population of the place.

It is not strange that personal safety was forgotten in the excitement of the scene. The tremendous brute, galled with wounds and repeated defeat, tore his way through the foaming water, glancing from side to side, in the vain attempt to avoid his foes, then rapidly ploughing up the stream he grounded on the shallows, and turned back frantic and bewildered at his circumscribed position. At length, maddened with suffering, and desperate from continued persecution, he rushed furiously to the

mouth of the stream, burst through two of the nets; and I threw down my gun in despair, for it looked as though his way at last was clear to the wide lake. But the third net stopped him, and his teeth and legs had got entangled in all. This gave us a chance of closer warfare with lances, such as are used against the wild buffalo. We had sent for this weapon at the commencement of the attack, and found it much more effectual than guns. Entering a canoe, we plunged lance after lance into the alligator, as he was struggling under the water, till a wood seemed growing from him, which moved violently above, while his body was concealed below. His endeavors to extricate himself, lashed the water into foam, mingled with blood; and there seemed no end to his vitality, or decrease to his resistance, till a lance struck him directly through the middle of the back, which an Indian, with a heavy piece of wood hammered into him, as he could catch an opportunity. My companion, on the other side, now tried to haul him to the shore, by the nets to which he had fastened himself, but had not sufficient assistance with him. As I had more force with me, we managed, with the aid of the women and children, to drag his head and part of his body on to the little beach, where the river joined the lake, and giving him the "coup de grace," left him to gasp out the remnant of his life on the sand.

I regret to say, that the measurement of the length of this animal was imperfect. It was night when the struggle ended, and our examination of him was made by torch-light. I measured the circumference, as did also my companion, and it was over eleven feet immediately behind the fore legs. It was thirteen feet at the belly, which was distended by the immoderate meal made on the horse. As he was only partly out of the water, I stood with a line at his head, giving the other end to an Indian, with directions to take it to the extremity of the tail. The length so measured, was twenty-two feet; but at the time I doubted the good faith of my assistant, from the reluctance he manifested to enter the water, and the fears he expressed that the mate of the alligator might be in the vicinity. From the diameter of the animal, and the representations of those who examined him afterwards, we believed the length to have been about thirty feet. As we intended to preserve the entire skeleton, with the skin, we were less particular than we otherwise should have been. On opening him, we found, with other parts of the horse, three

legs entire, torn off at the haunch and shoulder, which he had swallowed whole, besides a large quantity of stones, some of them of several pounds weight.

The night, which had become very dark and stormy, prevented us from being minute in our investigation; and leaving directions to preserve the bones and skin, we took the head with us and returned home. This precaution was induced by the anxiety of the natives to secure the teeth; and I afterwards found that they attribute to them miraculous powers in the cure or prevention of diseases.

The head weighed near three hundred pounds; and so well was it covered with flesh and muscle, that we found balls quite flattened which had been discharged into the mouth and at the back of the head, at only the distance of a few feet, and yet the bones had not a single mark to show that they had been touched.

I would observe, that the head, as it now appears, conveys a feeble impression of its size before it was divested of its integuments.

I returned shortly after to Manilla, and expected to have been followed by the bones and skin of the alligator. They were drying on a scaffold, near the place where he was killed, when a typhon, or hurricane, of unexampled severity, which laid low the cabin of the Indian and the tree of the forest, and covered the shores of the lake with the bodies of man, and beast, and fish, swept away the platform and whirled into the lake or the jungle, every fragment of our victim.

The head was an object of great curiosity at Manilla, nothing of similar size having been seen there; and on a visit which I subsequently made to Europe, I examined, with some attention, the museums of natural history, particularly those of France and England, without finding any thing of equal magnitude.

While the head was at Manilla, an English frigate arrived there that had been long on the East India station. The officers had, at Ceylon, killed an alligator of extraordinary size, the skeleton of which they intended to send to the British Museum. They expressed however their disinclination to do so, after seeing that from Halahala, which was much larger than the one they had taken.

In comparing notes with them respecting the nature and habits of this animal, I was struck with the similarity of the supersti-

tions prevailing at Ceylon and Luconia; such as the alligator swallowing a stone whenever he kills a human being, as if to keep account of his misdoings, and, after devouring the body, placing the head before him and weeping from remorse.

It is not strange that extravagancies like this should be current with so rude a people; but it is singular that two, remote from each other and without connection, should both give credit to the same absurdities.

The native of Luconia, the island on which Manilla is situated, is excessively fond of the marvellous. He is ever ready to give supernatural constructions to every thing that cannot be solved at once; and there is no limit to his credulity. One night, in the country, my attention was directed to a light midway on a mountain, which I naturally attributed to a fire made by some one who had lost his way—as proved to be the case—not so the Indians. It was too favorable an opportunity to let pass with such a common-place supposition. They said an anaconda had found a stone of inestimable value, and, according to his usual practice, when in such luck, was playing at cup and ball with it. They could see the gorgeous gem, sparkling with light, tossed into the air; and the serpent bounding from the earth, as he caught it in his mouth, or rapidly twining among the trees, as with wild glee, he pursued his game.

I sometimes visited a place so secluded and difficult of access, that probably no human feet had ever reached it. There the enormous vampire bat, or flying fox, slept away the hours of daylight; and hanging to the boughs by his hooked claws, with his head downward and his wings folded like a cloak about him, waited till night should enable him to look for the plantain, his accustomed food. There thousands of the animals congregated, and when disturbed by the report of a gun, rose with screams, darkening the air with their heavy flight, and encircling the woods they dared not leave. Little was required to invest a spot like this with mystery; and well might the islander fancy, as the black wings flapped like evil spirits around him, that he stood on unhallowed ground.

At the time of our expedition against the alligator, the periodical visitation of locusts, which occurs about once in seven years, was devastating parts of the island; and, on the following day, the place where I resided was doomed to share in the distress.

We were flattering ourselves that the scourge would not come near us, when the dark clouds were seen, far over the lake, approaching noiselessly, save in the rushing of wings, and soon the sun was hid, and night seemed coming before her time. Mile upon mile in length moved the deep broad column of this insect army; and the cultivator looked and was silent, for the calamity was too overwhelming for words. The sugar cane, the principal crop of that country, gave promise of unusual productiveness when the destroyer alighted. In a moment nothing was seen, over the extended surface, but a black mass of animated matter, heaving like a sea over the hopes of the planter. And when it arose to renew its flight, in search of food for the hungry millions who had had no share in the feast, it left behind, desolation and ruin. Not a green thing stood where it had been, and the very earth looked as though no redeeming fertility was left to it. Human exertions availed nothing against this enemy; wherever he came he swept like a consuming fire, and the ground appeared scorched by his presence. Branches of trees were broken by the accumulated weight of countless numbers; and the cattle fled in dismay before the rolling waves of this living ocean. The rewards of government and the devices of the husbandman, for his own protection, were useless. Myriads of these insects were taken and heaped together, till the air for miles was polluted, without apparent diminution of their numbers.

The typhon was the irresistible agent which at last terminated their ravages, and drove them before it far into the Pacific. This remedy prostrated what the locust had left, but still it was prayed for as a mercy, and received with thanksgiving.

Of the Philippine Islands, Luconia is the one best known; but the world of nature there is yet unexplored; and the few men of science who have been permitted to carry their researches into the interior, have either been too easily satisfied with the wonders they encountered at the outset, or have not been spared to give the result of their labors. The one best fitted for the work, who visited that country during my residence in it, was an Italian. He penetrated where the white man had not been seen since the earliest days of the colony, when the followers of Magellan made the circuit of the island, with the daring spirit of investigation which distinguished that age of discovery.

He made his way to the wandering negro tribes which roam through a tract of mountain country, near the middle of the island, and who, uninfluenced by the semi-civilization around them, pass an erratic life without fixed habitations, gathering their food from the wild fruit trees, and offering wide field for conjecture on their origin and insulated position.

The individual I allude to, returned from his interesting excursions, stored with most valuable information. His indefatigable spirit was undaunted at the great plan he had laid out before him, and he left Manilla with the determination to penetrate to the centre of Borneo—that unknown world, whose savage inhabitants have not been overcome or softened, even by the cupidity of commerce, and whose resources can only be imagined from its magnitude, situation, and the exceeding fruitfulness of its coasts. He had scarcely entered on his new discoveries, when approaching too near a volcano, he slipped into the hot ashes of its burning crater, which in a few days caused his death.

If, in recurring to some of the incidents of my life in Luconia, I have inclined to dwell on what may seem irrelevant to the object of this communication, it is that I am fond of remembering the days I have passed in the solitudes of that lovely land. The dreams of fancy have never pictured scenes of more romantic beauty than are there lavishly spread around;—where the principle of life is profusely scattered and every thing is glowing with animated being—where the bland air makes mere existence enjoyment; and the day, with its mild sky and refreshing sea breeze, gives place to the more serene night, with her clear brilliancy, when the eye looks deep into heaven, and the stars glitter with a radiance unknown in less genial climes—where the land wind rises, and is felt, but not heard, for the stillness of midnight is not broken as its soft breath comes from the untrodden depths of the wilderness, laden with the fragrance of the spice tree and the wild flower.

But in that luxurious region, nature at times shows herself in the power and sublimity of her convulsions, and awes by the earthquake, the tornado, and the thunder storm. Her hours of anger are fearful, but are soon forgotten as she resumes her almost permanent tranquillity.

Boston, Feb. 12, 1840.

ART. XV.—*Synopsis of a Meteorological Journal, kept in the city of New York for the years* 1838 *and* 1839, *including also the mean results of the last seven years;* by W. C. REDFIELD.

(Reported to the Regents of the University of the State of New York.)

THE observations which I have made on the direction of the surface winds, and also on the direction of the highest observed wind in the region of clouds, for periods of four hours duration, commencing at 6 A. M., and ending with 10 P. M., are comprised in the following tables.*

Monthly and annual results for the year 1838.

1838.—Months.	Observations of the surface winds, in periods of four hours.				Observations of highest observed wind in the region of clouds, in periods of four hours.			
	From N. E. quarter including N.	From S. E. quarter including E.	From S. W. quarter including S.	From N. W. quarter including W.	From N. E. quarter including N.	From S. E. quarter including E.	From S. W. quarter including S.	From N. W. quarter including W.
January, . .	19	7	91	36	5	3	119	15
February, . .	15	7	35	78	0	0	37	52
March, . . .	61½	19½	33½	34	11	1	25	59
April, . . .	27	16½	43	56½	0	4	32	80
May, ...	19	19½	79½	24	2	4	60	59
June, . . .	22½	46½	59½	17	4	5	83	29
July, ...	19	10	81½	39½	6	0	27	90
August, . . .	16	28½	56½	46½	1	0	39	77
September, . .	40½	21½	48½	27½	7	1	73	8
October, . . .	13½	12	63	43	1	8	63	33
November, . .	18	21	54½	51½	0	0	71	34
December, . .	11½	6	74½	54	0	0	84	31
Annual results,	282½	215	720	507½	37	26	713	567
Proportion in 1000,	164	125	417	294	28	19	531	422

* For summaries of the observations from 1833 to 1837 inclusive, see the Reports of the Regents of the University of the State of New York, made to the legislature in 1835 and 1837, and Am. Jour. of Science, Vol. XXVIII, pp. 154—159, and Vol. XXXIV, pp. 373—376.

Monthly and annual results for 1839: *to which are added the mean annual results from* 1833 *to* 1839 *inclusive.*

1839.—Months.	Observations of the surface winds, in periods of four hours.				Observations of the highest observed wind in the region of clouds, in periods of four hours.			
	From N. E. quarter including N.	From S. E. quarter including E.	From S. W. quarter including S.	From N. W. quarter including W.	From N. E. quarter including N.	From S. E. quarter including E.	From S. W. quarter including S.	From N. W. quarter including W.
January, . .	48	7	58	38½	0	17	35	41
February, . .	43½	9½	38	32½	4	1	16	40
March, . . .	37½	13½	40½	56	0	0	83	26
April, . . .	40	21	49	32	16	13	28	42
May, ...	32½	31½	48½	35½	0	5	42	65
June, . . .	20	28½	60½	40	3	0	42	81
July, . . .	2½	28	71	27	0	0	54	57
August, . . .	48	18	47	39	20	6	54	21
September, . .	12	18	71½	44½	5	3	72	17
October, . .	41½	17	7½	19	11	6	36	45
November, . .	43	13	27	63	5	0	59	43
December, . .	54½	6	11	75	20	1	28	39
Annual results,	423	211	529	502	84	52	549	517
Proportion in 1000,	253	127	318	302	70	43	456	430
Mean annual proportion for seven years, . .	216	127	382	275	53	24	565	358

Average proportion of easterly winds in 1000 for seven years, 343

" westerly winds " " " 657

The westerly winds being to the easterly, nearly as two to one.

Of the highest observed winds in the region of clouds, the proportion of easterly winds in 1000, is 77

Proportion of westerly winds, ... 923

Being nearly as *twelve to one.* Were not the movements of the higher strata sometimes concealed from view, particularly in easterly storms, the observations of the highest wind, it is believed, would be almost invariably from some western point of the horizon.

Table of the Monthly mean height of the Barometer in inches for each of the five daily observations recorded in the Journal during the year 1838.

1838.—Months.	6 A. M.	10 A. M.	2 P. M.	6 P. M.	10 P. M.	Monthly means.
January, . .	30 242	30.258	30.219	30.246	30.265	30.246
February, . .	30.044	30.072	30.017	30.021	30.046	30.040
March, . . .	30.138	30.164	30.129	30.121	30.146	30.140
April, . . .	30.056	30.079	30.029	30.025	30.054	30.049
May, . . .	29.983	29.999	29.971	29.955	29.976	29.977
June, . . .	30.033	30.053	30.034	30.022	30.048	30.038
July, . . .	30.180	30.094	30.065	30.049	30.070	30 072
August, . .	30.051	30.160	30.129	30.106	30.141	30.137
September, .	30.185	30.196	30.177	30.160	30.181	30.180
October, . .	30.073	30.085	30.045	30.050	30.084	30.067
November, .	30.236	30.277	30.219	30.220	30.243	30.239
December, .	30.094	30.143	30.094	30.121	30.150	30.120
Mean annual results,	30.110	30.132	30.094	30.091	30.117	30.109

Table of the Monthly mean height of the Barometer in inches for each of the five daily observations during the year 1839: *to which are added the mean average results for the last seven years.*

1839.—Months.	6 A. M.	10 A. M	2 P. M.	6 P. M.	10 P. M.	Monthly means.
January, . .	30.198	30.207	30.141	30.188	30.248	30.194
February, . .	30.222	30.281	30.205	30.206	30.224	30.227
March, . . .	30.116	30.163	30.122	30.112	30.142	30.131
April, . . .	30.089	30.115	30.075	30.057	30.084	30.084
May, . . .	30.031	30.065	30.020	30.000	30.017	30.027
June, . . .	29.971	29.999	29.974	29.968	29.989	29.980
July, . . .	30.033	30.040	30.024	30.016	30.033	30.029
August, . .	30.097	30.109	30.105	30.104	30.098	30.103
September, .	30.097	30.128	30.093	30.081	30.099	30.100
October, . .	30.281	30.316	30.263	30.241	30.266	30.273
November, .	30.160	30.203	30.154	30.161	30.185	30.173
December, .	29.948	29.980	29.935	29.954	29.974	29.958
Mean annual results,	30.104	30.134	30.092	30.091	30.113	30.106
Means for seven years,	30.101	30.123	30.088	30.086	30.108	30.101

It will be seen that the monthly means of the atmospheric pressure in 1838, are found highest in January and November; being equal to nearly thirty and a quarter inches of the barometric column. The lowest is found in May, being less than thirty inches. The highest monthly means for 1839 are found in February and October; the latter exceeding that of any month which I have observed; although not comprising the highest ranges of

the year. This effect appears to be due to the proximity of several violent storms of wind which passed over neighboring regions during the month, but did not visit New York. The mean for December of this year, is uncommonly low, and it is believed to be due to the dispersive effect exerted upon the atmosphere by the several violent and extensive storms which passed over us during the month.

The means of the several daily observations for seven years, show an excess in those assigned to 10 A. M.; also, a probable disproportion in those for 6 A. M. The former is probably owing chiefly to the fact that the observations for that hour, in most cases, are necessarily anticipated, and approximate more nearly to 9 A. M., and are taken at or near the time of the daily maximum of elevation; while the latter are perhaps slightly increased by the fact that for a portion of the year the hour assigned is too early for convenient observation. It is not improbable, that the mean of the two observations at 6 P. M. and 10 P. M., gives more nearly the true average pressure for the whole term of years, being 30.097; while the general mean in the table is 30.101.

My barometer has a glass cistern, and tube of $\frac{4}{15}$ths of an inch diameter, the scale for which was adjusted at a pressure of thirty inches and temperature of 68° F.; capacity of the tube to cistern $\frac{1}{4\,0}$; and the instrument is fitted up in a basement room, the cistern being less than ten feet above the mean level of the tide in New York harbor.

Through the kindness of Lieut. Riddell, R. A., the officer in charge of the new magnetic observatory in Canada, I had an opportunity, in September last, of comparing the adjustment of my barometer with one of Newman's portable iron-cisterned barometers, sent as a standard of comparison from the Royal Society. This comparison, made at the temperature of 59° F., showed an excess of 0.015 in. in my barometer, over that of the Royal Society. This agrees nearly with my own admeasurement; but I had allowed the excess as compensation for the capillarity of the tube, in order to avoid the necessity for this correction. If, however, this difference is to be deducted from the above general mean, it will give for the mean annual pressure at New York, 30.086 inches; or, if the mean of the hours of 6 and 10 P. M. be taken, we have 30.082 in. This is without any correction for temperature. The mean temperature of the instrument for the entire period is supposed to be about 68° Fahrenheit.

A Table showing the Monthly Maximum and Minimum and Range of the Barometer at New York for the year 1838.

1838.—Months.	Monthly maximum and date.		Monthly minimum and date.		Monthly range.
January, -	1st, winds light, followed by good weather,	30.58	19th, wind S. S. W.; change of a S. E. storm,	29.47	1.11
February, -	1st, after a long northwester, - - -	30.46	16th, wind N.; veering of a N. E. storm, -	29 13	1 33
March, - -	4th, wind light and var.; a S. E. storm follows,	30 61½	29th, wind W., change of storm from N. E. by N.,	29.41	1.20½
April, - -	17th, wind light; a S. E. storm follows, -	30.51	9th, wind W. S. W., change of easterly storm,	29.69	.82
May, - -	15th, wind S. W.; a storm before and after,	30.40	5th, easterly storm, - - - - - -	29.53	.87
June, - -	20th, closing of thick easterly weather, -	30.34	5th, wind N. E., close of easterly gale, -	29.49	.85
July, - - -	14th, after a low barometer; follows fair, -	30.39	30th, wind W. N. W., a fair weather period,	29.80	.59
August, - -	20th, closing up of the storm of 16th, - -	30.40	16th, change of S. E. storm to N. W., -	29.77½	.63½
September,	26th, strong easterly winds and rain, - -	30.50	13th, N. E. gale, hurricane at sea, - -	29.70	.80
October, -	17th, preceded and followed by storms, -	30.59½	11th, change of easterly storm, - - -	29.59	1.00½
November, -	11th, closing up of a storm, - - -	31.04½	5th, wind N., veering of N. E. storm, -	29.59	1.45½
December, -	31st, closing up of a slight storm, - -	30.99½	23d, change of southerly storm, - - -	29.54	1.45½
Annual results,	November 11th, - - - - - - -	31.04½	February 16th, - - - - - - -		1.91½

In this Table the correction for variation in the cistern is made in the entries.

The maximum for the year was the greatest which had been observed from the commencement of my observations; it having followed the closing or westerly wind of a southeast storm which appeared two and a half days previous; and for five days following the barometer did not fall below 30 inches. The maximum of this atmospheric freshet was observed at Hudson, Ohio, by Prof. Loomis, on the 10th of November, at 11 A. M.; at Ogdensburgh, N. Y., by John H. Coffin, on the 11th, about 8 A. M.; at Montreal, L. C., by J. S. M'Cord, from 9 A. M. till noon of the 11th; at New York, at 9 A. M.; at Providence, R. I., at 10 A. M. or later. In lat. 40° 34′, lon. 55° 35′, on the 14th, by Joseph C. Delano; and on the 16th, by the steamer Liverpool, latitude and longitude unknown. At the close of December there was a still greater rise of the barometer, which followed a storm of but moderate intensity, and reached its maximum on the first of January, 1839.

The greatest fall of the barometer in 1838, was on the 16th of February, at 6 P. M., under the veering of a N. E. storm to W. N. W. The wind during the greater part of the 16th hung at N., the barometer falling with a steady fall of frozen *rain drops* or small hail, while the thermometer was 9° to 11° below the freezing point; showing, as I think, the presence of a warmer stratum or current of wind in the region of clouds. When the wind had veered to N. W. the barometer commenced rising.

A Table showing the Monthly Maximum and Minimum of the Barometer at New York for the year 1839: *with the Range for seven years, from* 1833 *to* 1839 *inclusive.*

1839.—Months.	Monthly maximum.		Monthly minimum.		Range.
January, - -	1st, follows a light S. E. storm, - - -	31.07½	26th, change of a violent S. E. gale, -	28 88	2.19½
February, - -	12th, follows a light storm, - - - -	30.57	28th, change of E. N. E. storm by N. to N. W.,	29 39	1.18
March, - - -	31st, follows a light E. N. E. storm, - -	30.70	9th, change of an easterly storm, - -	29.43	1.27
April, - - -	3d, strong settled E. N. E. winds, - -	30 45	17th, N. E gale changing by N., - -	29 53	.92
May, - - -	8th, settled easterly winds, - - -	30 38	3d&28th, change of S. E. storm, light east'ly do.	29 60	.78
June, - - -	7th, light S. wind, preceded and foll'd by storms,	30.30	22d, light southerly storm, - - -	29.70	.60
July, - - -	18th, between two light S. S. E. storms, -	30.31	11th, change of S. S. E. storm, - -	29 70	.61
August, - - -	14th, settled easterly winds, - - -	30.38	9th, change of a light S. E. storm, -	29.68	.70
September, - -	3d, do. do. do. - - -	30.47	9th, change of a light southeasterly storm,	29.80	.67
October, - - -	6th and 21st, do. do. - - -	30 78	30th, edge of a neighboring storm, - -	29.87	91
November, - -	22d, between two storms, - - - -	30 86	5th, change of an E. gale to W., - -	29 50	1.36
December, - -	31st, closing up of storm of 28th, - -	30.36	28th, lull and change of a hard easterly gale,	28.89	1.47
Annual results, -	January 1st, - - - - - - -	31.07½	January 26th, - - - - - -	28 88	2.19½
Do. correct. 1-40 for var. in cist.	As corrected, - - - - - - -	31 10	As corrected, - - - - - -	28 85	2.25
Range for seven years,	January 1st, 1839, - - - - -	31.10	January 26th, 1839, - - - -	28 85	2.25

The extraordinary accumulation of atmosphere on the first of January reached its maximum at 10 A. M., the height of the barometer, as corrected, being 31.10 inches. The barometer also continued above 30 inches for six days. A severe gale is known to have appeared in the Atlantic on the first of January not far from our coast; and it is not improbable this was the same storm which on the 6th caused so much destruction on the coast of England. A southeast storm had also preceded this unusual rise of the barometer.

The greatest depression of the barometer which I have yet observed, took place on the 26th of January; the mercury then falling to 28.85 inches at the crisis or change of a violent southeast gale.* This fall of the barometer was from a previous elevation of 30.43 inches, and took place for the most part within twenty four hours; the rapidity of descent being in this case proportioned to the violence of the gale. Its rise, however, as is not uncommon in the case of great overland storms, was prolonged to a much greater period, as was also the less violent

* A nearly equal fall of the barometer took place in the violent storm of December 23th.

westerly wind which followed or closed up the easterly gale. This storm broke up the heavy ice in the Hudson for ten miles below Albany, and will long be remembered for the damages which it occasioned. It is not a little remarkable that the maximum, minimum and extreme range of the barometer for a period of seven years, should all have occurred in this month.

The fluctuations of the barometer and other phenomena which characterize our great storms, can only be thus cursorily alluded to in this place; but they have strong claims to the attention and inquiries of all observers; and when duly investigated, will probably add more to our knowledge of the laws of storms and atmospheric changes than all the mean results of instrumental observations which have been so industriously sought by philosophers and men of science. Of the available means for ascertaining these phenomena, few are more promising than the system of observation which is organized under the direction of the Regents of the University. It is now only necessary, that accurately adjusted barometers be furnished for two or three selected stations in each of the senatorial districts, and that the observations of this instrument, for fixed hours, be returned to the Regents with the usual annual reports.

New York, January 22, 1840.

ART. XVI.—*Notice of a Manual of Chemistry, containing the principal facts of the science, in the order in which they are discussed and illustrated in the Lectures at Harvard University, N. E., and several other colleges and medical schools in the U. States. Compiled and arranged as a text-book for the use of Students and persons attending Lectures on Chemistry. Third edition, comprising a summary of the latest discoveries, as contained in the works of Brande, Turner, Thomson, and other distinguished Chemists, illustrated with upwards of two hundred engravings on wood;* by JOHN W. WEBSTER, M. D., Erving Professor of Chemistry and Mineralogy in Harvard University. 1 Vol. 8vo. pp. xxii, 556. Boston: Marsh, Capen, Lyon & Webb. 1840. (Communicated.)

Two editions of the Manual of Chemistry by Dr. Webster, have already been presented to the public, by means of which it has become extensively known among men of science; its char-

acter has long since been established, and its merits as a work of reference and a text-book have been admitted and duly appreciated. Indeed, as a text-book it was introduced into many of our colleges, and continued to be employed in them so long as copies could be procured. The second edition was long ago exhausted, and although the demand for the work continued unabated to the last, such were and are the arduous duties of the author, as Professor of Chemistry in the University at Cambridge and in the Medical School at Boston, that we have been somewhat apprehensive lest sufficient leisure should not be left him to prepare another edition, considering the labor required properly to digest the amount of material which has so abundantly accumulated of late years, and bearing in mind the many discoveries in, and important additions to, the science that it was necessary to post up. We are however not only highly gratified to find our fears at length happily and satisfactorily removed, but are also much pleased to observe the improved appearance of the work, and to notice the many important and judicious changes that have been made in it.

This edition may indeed be almost considered as an entirely new work, so thorough a revision is evident on every page; affording ample evidence of the unremitted care, patient research, sound judgment, and nice discrimination, that were exercised to render it in all respects what a Manual should be; perspicuous, comprehensive, and withal concise. The author never sacrifices sense to sound; he never leads the reader away from the subject; and as he is dealing with facts, he proceeds in a strictly philosophical manner. He avoids the two extremes; being neither so brief as to bewilder and confuse, nor so prolix as to weary and disgust. Frequently, whilst examining its pages, have we been forcibly reminded of the truth of a remark made by the celebrated surgeon, Pott. "Any man," observed he, "may give an opinion, but it is not every mind that is qualified to collect and arrange important facts." All the great principles of the science are clearly laid down, and most of the recent discoveries are incorporated in its pages. So solicitous indeed has Dr. Webster evidently been to present every thing of value that was made known in his favorite science to the moment of sending the last page to press, that it will be found, by referring to the Addenda and Appendix, he has incorporated every discovery of any worth

which had been announced, down almost to the very day of publication. This edition is better printed than those were that preceded it. There is one change that in an especial manner pleases us, and for which, unless we greatly err, he will receive the thanks of every student; we mean the introduction of neat and well executed wood cuts into the body of the work, instead of the insertion of the illustrations at the end. The advantage of the former over the latter plan is too obvious to require designating.

In a short preface, or advertisement as it is styled, the author informs us that owing to the adoption of Dr. Turner's Elements into several institutions, (the Manual being out of print,) and knowing that Dr. T. was preparing a new edition for the press, he was induced to relinquish, for the time, the publication of the present work. Subsequently, he was prompted to renew his labor and perfect his design, from ascertaining that Dr. Turner's work was *left incomplete* at the time of the decease of that good man and most excellent chemist. That he *was* prompted to finish that which he had undertaken we rejoice at; because the "Elements," admirable as is the work, is not practical; it is not a work that a beginner can follow *experimentally;* and yet this course is the only one whereby chemistry can be profitably and satisfactorily studied, and thoroughly and advantageously taught.

The present work, we are told by Dr. Webster, is *compiled* and *arranged* by him. Such a task, if faithfully and judiciously executed, requires no less intimate a knowledge of the subject, and demands a far greater amount of labor than the writing of an original treatise. Indeed, we can hardly say that we have or can have an entirely original treatise on practical chemistry. All of our manuals and systems are in truth, for the most part, compilations; they must from the very nature of the subject be made up of the thousand facts, experiments, discoveries, deductions, &c., that are to be found scattered through a vast number of scientific journals, transactions, memoirs, and other publications.

Whilst perusing the volume, we continually see abundant evidence that the author spared no pains in collecting, examining, and duly arranging his materials, and that he often condensed elaborate papers, clothing their substance in language of his own, the more surely to bring them within the comprehension of the reader. Some may think that he is occasionally too concise, but his references to the original sources are always given, so that the

student, if not satisfied with the condensed or abridged account, knows where to seek for farther details. It is pleasing to observe how scrupulously the author "renders unto Cesar the things that are Cesar's," and bestows honor upon whom honor is due, by crediting every important observation or discovery to its rightful owner; an act of justice that is too often neglected.

Dr. Webster alludes to Prof. Bache, the accomplished editor of the American edition of Turner's Elements, in well merited terms of commendation. To Mitchell, Hare, Silliman, Jackson, Hayes, Torrey, and others, that we with pride rank among our prominent scientific men, he gives due acknowledgment for such of their labors as come within the scope of his work. The various valuable pieces of chemical apparatus figured and described, which are the products of the inventive genius of some of our own scientific men, are attributed to those to whom he is indebted for them; and the same just course is pursued in regard to many of the processes and experiments mentioned.

The arrangement of the subjects in this edition is quite different from that which was followed in either of the former editions. It is very nearly that of Turner; and a better model could not have been selected. The first chapter treats "of the Powers and Properties of Matter, and of the general laws of chemical changes;" and in it are incorporated the new facts relating to heat, electricity, and galvanism. The discoveries and deductions of Dr. Faraday are given principally from the lucid and satisfactory statements of Dr. Turner, some additions being made to the account from Faraday's later papers. The very curious and interesting observations of Forbes, on the *polarization* of heat, are also referred to in this chapter.

The second chapter is a highly important one, inasmuch as it contains the very *alphabet* of the science, without a knowledge of which every thing would be as unintelligible and as incomprehensible as the alchemistic gibberish of former days; and also a full description of the apparatus to be used, and the manner of using it, without a familiarity with which, all previous knowledge would be of little practical advantage. This chapter is divided into three sections; the first embracing an outline of the new nomenclature, with an explanation of the principles upon which it is founded; the second, a detailed account of "Apparatus and Manipulation," fully and clearly illustrated by explanatory cuts;

the third describes the various methods of estimating the specific gravities of solids, liquids, and gases. The author in this chapter has not confined himself exclusively to an account of matters as they are at the present time, but to a certain extent has combined historical with practical information; thus furnishing the student with sufficient knowledge of the views and opinions entertained at various periods, to enable him easily to trace the progress of the science through various devious paths to its present state of advancement.

The third chapter is occupied with "Inorganic Chemistry," and contains a history, an account of the nature and properties, and the methods for the obtaining, of oxygen, hydrogen, nitrogen, carbon, sulphur, chlorine, &c. &c., and also a description of their compounds. The various theories of combustion are herein spoken of, the analysis and synthesis of water shewn, eudiometry is described, and numerous other important topics are discussed. Under the section on carbon, whilst speaking of carbonic acid, the important results of the experiments of Dr. Mitchell of Philadelphia, on the liquefaction and solidification of this gas, are stated. On Plate I, facing page 13, will be found represented the apparatus of Mr. Adams, which was contrived for the purpose of obtaining the gas in a solid state and on a large scale. It is accompanied by a full description of every part of the generator and receiver, of the proportions of the materials used, of the method of charging the generator, and of the manner of obtaining the solid result. It is the only account of this apparatus which we have seen; and it seems hardly credible that it can sustain uninjured, the immense pressure to which it is subjected. It has however been fully tested, and we presume is the same with which Dr. Webster obtained the very large quantities of this solidified *gas*, which we understand he exhibited in his lectures before several societies during the winter just past.

The fourth chapter includes, under seven sections, an account of the metals. All of the important characters and properties of each are given, and then follow descriptions of the oxides, chlorides, &c.

In the fifth chapter we find the salts of the metals. These are arranged under four orders; the author very wisely adopting the division into oxy-salts, hydro-salts, sulphur-salts, and haloid-salts, which we deem the best that has yet been devised. The com-

position of these substances, and indeed of all other important ones, is given in symbolic language after the name of each, as is also the atomic weight. This plan is a decided improvement over the tabular arrangement introduced by Turner. It saves the student much trouble, and the vexatious labor he would have to undergo in referring back to ferret out the name of a substance contained somewhere, in a long table. The descriptions of the metallic salts are selected mainly from the excellent ones of Turner and Liebig.

The four remaining chapters treat of organic chemistry, under which are embraced both animal and vegetable chemistry. This reminds us to remark, that Dr. Webster has rejected the old divisions just alluded to, and recognizes in his Manual two great divisions only; viz. the chemistry of unorganized and that of organized bodies. Under the second general division, the author, manifestly with great labor, has compressed within the compass of one hundred and fifty pages, most of the important matter to be found in the late elaborate and masterly volume of Dr. Thomson. That volume contains upwards of one thousand closely printed pages, and of course is a very unwieldy tome; we therefore are under no small obligations to Dr. W. for furnishing us with so excellent an abridgment of it. He also introduces, in this part of the work, the views and theories of Liebig. Although the chemistry of animal substances is very important, still, as the time devoted to this department in most of our institutions and in almost all courses of lectures, is very short, Dr. W. has not thought best to enter much into detail in the chapter appropriated to this subject. In this portion of the work he has followed Dr. Reid, and what has been furnished will be found amply sufficient for all purposes of elementary instruction.

As has already been incidentally mentioned, numerous important addenda are placed near the end of the work, followed by an Appendix, made up of tables and other valuable matter, a very copious general index, and an index of cuts.

We have also already alluded in very general terms to the fact of this volume being liberally supplied with wood engravings; they amount to upwards of *two hundred* in number. The vast number of experimental illustrations, and the careful directions as to manipulations, many of which are, if we mistake not, original, and many others we know have not hitherto been introduced into

works of general use, will greatly enhance the value of this Manual, and render it the more acceptable both to teachers and students. The arrangements of apparatus, and the descriptions of the figures are unusually full and complete. In the frontispiece we find represented Dr. Charles T. Jackson's newly invented oxy-alcohol and air-blast lamp, which possesses great power. We also find in the frontispiece a figure of a new air-pump of great simplicity and beauty, recently made for Harvard College. It was constructed by N. B. Chamberlain, Philosophical Instrument Maker, School street, Boston; and we learn from the Manual that it will freeze water on Leslie's plan, with perfect ease and great rapidity. It affords us much pleasure to direct attention to this instrument, as we can well remember how extremely difficult it was, until within a few years, to get chemical and philosophical apparatus of good quality made in this country. We were often compelled to forego the pleasure of prosecuting our investigations, and of following along the paths newly opened by our transatlantic brethren; to make the essay with inferior instruments and the almost positive knowledge that we should in consequence fail of attaining the desired result; or to lose much valuable time and expend much money in ordering the requisite instruments from Europe. This difficulty was owing in part, undoubtedly, to our artists not having been duly encouraged to exert their ingenuity and skill. Dr. Webster informs us that all the apparatus figured and described in his work, is or can be made by Mr. Chamberlain. As therefore there is no longer any deficiency of skill or ingenuity upon the part of artists, we trust there will be no withholding of patronage upon the part of our men of science; and most sincerely do we hope, for the honor of our country, that public institutions as well as individuals, will be more patriotic than to send abroad for apparatus, when it can be so well and so cheaply made under their own inspection at home.*

We cannot close this notice, without expressing a desire that Dr. Webster would abridge his Manual for the use of the higher classes of schools and of academies. A good text-book is much needed in such seminaries.

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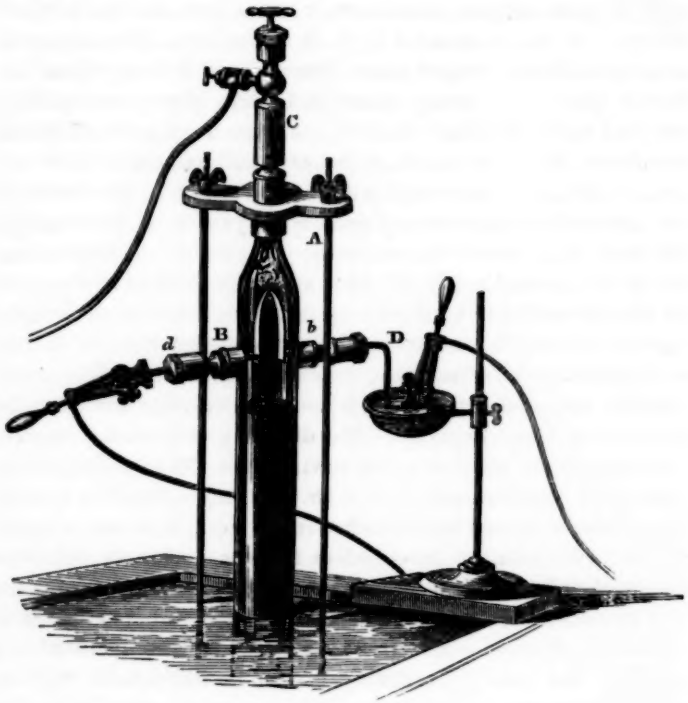
* It is but justice to our excellent artists and to the progress of practical as well as theoretical science among us to say, that our principal cities now contain establishments, in which almost every kind of philosophical apparatus is manufactured with elegance and skill.—*Eds.*

ART. XVII.—*Engraving and Description of an Apparatus for the Decomposition and Recomposition of Water, employed in the Laboratory of the Medical Department of the University of Pennsylvania;* by R. HARE, M. D., Prof. of Chem. Read before the Amer. Philos. Society, Dec. 7, 1838.



HAVING to illustrate the decomposition and recomposition of water to a class of between three and four hundred pupils, I have found it expedient to exhibit the process on an extensive scale.

For many years I have employed a glass tube, of about an inch and a half in bore, and about two feet in height.

The tube (A), which I have used for three years past, has been furnished with two tubulures (B, *b*), about three inches below the upper extremity, where it converges to an apex, having an aperture not larger than a goose quill. Upon this apex there is an

iron cap, in which a female screw is wrought so as to allow a large iron valve cock (C) to be screwed to it.

Upon the tubulures also iron caps are cemented, which are so wrought as, with the aid of appropriate screws, to constitute stuffing boxes.

Through each of these a platina rod (D, *d*) is introduced, and fastened to plates of platina, to act as "*electrodes*," agreeably to the language of the celebrated Faraday.

The tube being supported over the mercurial cistern, by means of a communication with an air pump, through the valve cock and flexible leaden pipe, the bore of the tube is exhausted of air, so as to cause the mercury to take its place.

The mercury is so far displaced by a solution of borax, consisting of equal parts of water and saturated solution of that salt, as to sink the surface of the column of metal in the tube about an inch or more below the "electrodes." The projecting end of one of the rods (D, *d*,) to the other ends of which the "electrodes" are severally attached, is bent at right angles outside of the tube, so as to enter some mercury in an iron capsule, supported purposely at a proper height, and communicating with one end of my deflagrator of an hundred pairs of Cruickshank plates of about eight inches by foureteen. Of course the rod of the other electrode must have a communication with the other end of the deflagrator. Under these circumstances, if the circuit be completed by throwing the acid on the plates of the deflagrator, a most rapid evolution of hydrogen and oxygen will ensue in consequence of the decomposition of the water, so that within a few seconds, several cubic inches of gas will be collected.

The action being now suspended by throwing the acid off the plates, and the foam being allowed to subside, the resulting gaseous mixture may be ignited, and of course condensed, by completing the circuit again as at first, and at the same time causing the ends of the "electrodes" to come into contact with each other, and thus to produce a spark.

This contact is effected by causing a very slight movement in the rod, bent at right angles, and entering the mercury in the iron capsule. Of course the process may be repeated as often as can be reasonably desired.

ART. XVIII.—*Improved Process for obtaining Potassium;* by ROBERT HARE, M. D., Prof. of Chem. in the Univ. of Penn. Read before the Amer. Philos. Society, Dec. 7, 1838.

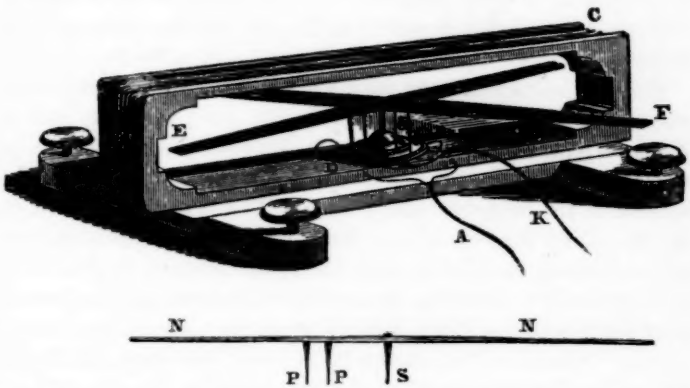
IN evolving potassium, agreeably to Brunner's plan, I have substituted for the luting usually employed to protect the iron bottle, a cylinder of iron, which is made to surround the bottle; also a disk of the same metal, of a diameter and thickness equal to that of the cylinder.

The disk is supported by bricks of kaolin. The bottle being vertical, the blast acts more equably on the surface of the iron, and the operator can, by additional fuel, protect any part from that undue exposure, to which the under surface is always liable, when the bottle is horizontal.

The potassium is received into an iron tube, of which the bore is two inches in diameter. This tube screws at one end into the bottle, and at the other is closed by a perforated plug, terminating in a small orifice. To this a leaden tube is fitted, which is so adjusted by bending, as to cause the vapor resulting from the burning of the gas, to go into the ash-hole. By these means the hydrogen, being ignited as soon as it comes over, serves as an index of the success and progress of the process. In this way no resort to naphtha is in the first instance necessary. The potassium is extricated from the tube by cooling it by affusion of water, detaching it from the bottle, and then closing the end thus exposed by a cap, in which a suitable conical female screw is wrought.

The part of the tube containing the potassium is then made in a vertical position to occupy the axis of a cylindrical furnace, the end terminating, as above mentioned, in a tapering plug, being lowermost, and projecting below the bottom of the furnace. Before the temperature reaches redness, globules of the metal begin to descend; but to extricate the last portion, a white heat is requisite. The potassium may be received in bottles, kept full of hydrogen by a constant current, or in naphtha. The first portion, which descends before the temperature is high, can be more easily received without naphtha than the latter portion.

ART. XIX.—*Engraving and Description of a Rotatory Multiplier, or one in which one or more Needles are made to revolve by a Galvanic Current;* by R. HARE, M. D., Prof. of Chem. in the Univ. of Penn. Read before the Amer. Philos. Society, Dec. 7, 1838.



THE preceding engraving represents a rotatory galvanometer, or multiplier, which I contrived in November, 1836, and which must have value as an addition to the amusing, if not to the useful implements of science. It is well known that by passing a temporary discharge through the coil of a multiplier, the needle may be made to perform a revolution, whereas if the current be continuously applied, the movement is checked as soon as the situation of the poles is reversed. To produce a permanent motion, the discharge must be allowed to take place only when the poles are in a favorable position, relatively to the excited coil. This object I attained by means of two pins, descending from the needle perpendicularly, so as to enter two globules of mercury, communicating, on one side, with a galvanic pair, on the other with the coil of the multiplier. In the next place, by winding over the first coil, another of similar length, but in a direction the opposite of that in which the first coil was wound, I was enabled, by two other globules, situated so as to communicate severally with the lower ends of the pins, at the opposite side from that on which the first mentioned globules were, to cause an impulse at every semi-revolution.

The one coil being wound to the right, the other to the left, the alternate effect of each upon the needle was similar in opposite

parts of the orbits described by the pins. Lastly, a second needle, furnished with pins in like manner, being fastened at right angles to the first, so as to form with it a cross, as represented in the engraving, each needle is made to receive two impulses during every revolution. Hence one of Danell's sustaining batteries, as made by Newman, is quite adequate to cause a revolution as rapid as consistent with a due degree of stability in the mercurial globules employed.

One end of each coil, by means of the branching wire A, communicates with one pole of the galvanic pair; the other ends of the coils terminate in mercurial globules contained in cavities on opposite sides of the wooden disc G, upon the centre of which the spindle of the magnetic needle rests. The branches of the wire K proceeding from the other galvanic pole, terminate in globules situated in the vicinity of those above mentioned, so that as the needles revolve, the pins proceeding therefrom perpendicularly may touch a pair of the globules first on one side and then on the other. Whenever this contact takes place, the circuit is completed, and a discharge is effected through one or the other of the coils of the multiplier.

Supposing E and F to be north poles, a discharge through one of the coils will cause E to move off a quarter of a circle, or more. As this ensues, the pins of F will come in contact with the globules which those of E touched before. Of course F will be propelled so as to cause the pins of E to reach the pair of globules at G, which, completing the circuit of a coil wound in a way the opposite of that first mentioned, concurs with that coil in its influence, so as to promote the rotation previously induced. The same result ensues when the pins proceeding from F come in contact with the globules situated at G, and when E returns to its original starting point. It follows, that by a repetition of the process the galvanic action is sustained. The phenomenon is as well illustrated by employing the single needle, N, N, as by two, but the most pleasing and energetic effect is produced by the crossed needles. In this simple form the spindle on which the needle rests and revolves is represented at S; the pins at P, P. Each coil, consisting of copper bell wire, is about thirty feet in length, and is contained in the groove C. The frame of the multiplier is constructed of mahogany and is levelled by the milled headed screws, on the ends of which it is supported.

ART. XX.—*Crania Americana; or a Comparative view of the Skulls of various Aboriginal Nations of North and South America; to which is prefixed an Essay on the Varieties of the Human Species, illustrated by seventy-eight plates and a colored map;* by SAMUEL GEORGE MORTON, M. D., Professor of Anatomy in the medical department of Pennsylvania College, at Philadelphia, &c. &c. Philadelphia: J. Dobson. London: Simpkin, Marshall & Co. Letter Press, pp. 296, folio, 1839.

WE hail this work as the most extensive and valuable contribution to the natural history of man, which has yet appeared on the American continent, and anticipate for it a cordial reception by scientific men not only in the United States, but in Europe. The subject is one of great interest, and Dr. Morton has treated it in a manner at once scientific and pleasing, while the beauty and accuracy of his lithographic plates are not surpassed by any of the modern illustrations of science.

The principal design of the work, says Dr. Morton, has been "to give accurate delineations of the crania of more than forty Indian nations, Peruvian, Brazilian and Mexican, together with a particularly extended series from North America, from the Pacific Ocean to the Atlantic, and from Florida to the region of the Polar tribes. Especial attention has also been given to the singular distortions of the skull caused by mechanical contrivances in use among various nations, Peruvians, Charibs, Natches, and the tribes inhabiting the Oregon Territory." His materials, in this department, are so ample, that he has been enabled to give a full exposition of the subject. He has also bestowed particular attention on the crania from the mounds of this country, which have been compared with similar relics, derived both from ancient and modern tribes, "in order to examine, by the evidence of osteological facts, whether the American aborigines, of all epochs, have belonged to one race, or to a plurality of races."

The introductory Essay, "on the varieties of the human species," occupies ninety-five pages. It is learned, lucid, and like the whole work, classically written. The author notices the great diversities of opinion that have existed among naturalists regarding the grouping of mankind into races; Linnæus referred all the human family to five races; Buffon proposed six great di-

visions; subsequently, however, he reduced it to five; while Blumenbach, adopting the arrangement of Buffon, has changed the names of some of the divisions, and designated, with greater accuracy, their geographical distribution. Cuvier admitted three races only, the Caucasian, Mongolian and Ethiopian; while Malté Brun enumerates sixteen. A French professor, Broc, in his Essai sur les Races Humaines, published in 1836, has attempted to establish several *sub-genera*. The cause of these wide diversities of opinion obviously lies in the imperfect knowledge yet possessed of the subject.

Dr. Morton adopts the arrangement of Blumenbach in so far as regards the great divisions, substituting, however, the word *race* for the term "variety" of the German author, and changing the order in which Blumenbach considers some of them. He considers the human species as consisting of *twenty-two* families, which he arranges under the heads of the Caucasian, Mongolian, Malay, American, and Ethiopian races.

I. "The Caucasian Race is characterized by a naturally fair skin, susceptible of every tint; hair fine, long and curling, and of various colors. The skull is large and oval, and its anterior portion full and elevated. The face is small in proportion to the head, of an oval form, with well proportioned features. The nasal bones are arched, the chin full, and the teeth vertical. The race is distinguished for the facility with which it attains the highest intellectual endowments."

The subdivisions of this race are into—1st. The *Caucasian;* 2d. The *Germanic;* 3d. The *Celtic;* 4th. The *Arabian;* 5th. The *Lybian;* 6th. The *Nilotic,* (Egyptian;) and 7th. The *Indostanic* families.

II. "The Mongolian Race. This is characterized by a sallow or olive colored skin, which appears to be drawn tight over the bones of the face; long, black, straight hair, and thin beard. The nose is broad and short; the eyes are small, black, and obliquely placed, and the eye-brows arched and linear; the lips are turned, the cheek bones broad and flat, and the zygomatic arches salient. The skull is oblong-oval, somewhat flattened at the sides, with a low forehead. In their intellectual character the Mongolians are ingenious, imitative, and highly susceptible of cultivation.

The subordinate divisions are into—8th. The *Mongol-Tartar;* 9th. The *Turkish;* 10th. The *Chinese;* 11th. The *Indo-Chinese;* and 12th. The *Polar* families.

III. "The MALAY RACE. It is characterized by a dark complexion, varying from a tawny hue to a very dark brown. Their hair is black, coarse, and lank, and their eye-lids are drawn obliquely upwards at the outer angles. The mouth and lips are large, and the nose is short and broad, and apparently broken at its root. The face is flat and expanded, the upper jaw projecting, and the teeth salient. The skull is high and squared or rounded, and the forehead low and broad. This race is active and ingenious, and possesses all the habits of a migratory, predaceous and maritime people."

The subdivisions embrace—13th. The *Malay;* and 14th. The *Polynesian* (or South Sea Island) families.

IV. "The AMERICAN RACE is marked by a brown complexion, long, black, lank hair, and deficient beard. The eyes are black and deep set, the brow low, the cheek bones high, the nose large and aquiline, the mouth large, and the lips tumid and compressed. The skull is small, wide between the parietal protuberances, prominent at the vertex, and flat on the occiput. In their mental character the Americans are averse to cultivation, and slow in acquiring knowledge; restless, revengeful, and fond of war, and wholly destitute of maritime adventure."

The families into which this race is subdivided, are two: 15th. The *American;* and 16th. The *Toltecan.*

V. "The ETHIOPIAN RACE is characterized by a black complexion, and black, woolly hair; the eyes are large and prominent, the nose broad and flat, lips thick, and the mouth wide; the head long and narrow, the forehead low, the cheek bones prominent, the jaws projecting, and the chin small. In disposition, the negro is joyous, flexible, and indolent; while the many nations which compose this race present a singular diversity of intellectual character, of which the far extreme is the lowest grade of humanity.

This race is divided into—17th. The *Negro;* 18th. The *Caffrarian;* 19th. The *Hottentot;* 20th. The *Oceanic Negro;* 21st. The *Australian;* and 22d. The *Alforian* families. The latter family is most numerous in New Guinea, the Moluccas and Magindano.

The map which precedes the work, shows the geographical distribution of the five races of men; and the lines of demarcation are those indicated by Professor Blumenbach, as separating the different races in the primitive epochs of the world. These divisions, of necessity, are only approximations to truth. The *boundary* between the *Caucasian* and *Mongolian* races is ex-

tremely vague. The line adopted runs from the Ganges in a northwestern direction to the Caspian Sea, and thence to the River Obi, in Russia. "At a comparatively recent period, however, several Mongolian nations have established themselves in Europe; as the Samoyedes, Laplanders, &c." The *Ethiopian line* is drawn north of the Senegal River, obliquely east and south to the southern frontier of Abyssinia, and thence to Cape Guardafui, thus embracing the Atlas Mountains. "Of the latter, little is known; but many negro nations inhabit to the north of them, at the same time that the Arab tribes have penetrated far beyond them to the south, and in some places have formed a mixed race with the natives."

Dr. Morton gives a brief but clear description, extending to his 91st page, of the leading characteristics of each of these families, accompanying his text by references to the authorities from which the information is drawn. The labor and accuracy of the true philosopher are here conspicuous. After perusing these details, however, we are strongly impressed with the conviction that this branch of science is still only in its infancy. The descriptions of the mental qualities which distinguish the different families of mankind, given even by the best travellers, are vague and entirely popular. There is scarcely an instance of the specification of well defined mental faculties, present or absent in the races, or possessed in peculiar combinations; nothing, in short, which indicates that the travellers possessed a mental philosophy under the different heads of which they could classify and particularize the characteristic qualities of mind which they observed, as the botanists describe and classify plants, or the geologists minerals. The anatomical characters of the races, also, are still confined to a few particulars, and many even of these have been drawn from the inspection of a very limited number of specimens. The subject, however, possesses so much inherent interest and importance, that we may expect rapid advances to be made in its future development.

The unity of the human species is assumed by Dr. Morton. It is known that the *black* race possess an apparatus in the skin, which is wanting in that of the *white* race. Flourens states that there "are, in the skin of the *white* race, three distinct laminæ or membranes—the *derm*, and two *epiderms*; and in the skin of the *black* race, there is, besides the *derm*

and the two epiderms of the *white* race, a particular apparatus, an apparatus which is altogether wanting in the man of the *white* race, an apparatus composed of two layers, the external of which is the seat of the *pigmentum*, or coloring matter of negroes."* "The coloring apparatus of the negro is always found in the mulatto." Flourens adds, "The *white* race and the *black* race are then, I repeat, two essentially distinct races. The same is true of the *red*, or American race. Anatomy discovers, under the second epiderm of the individual of the *red*, *copper-colored*, *Indian* or *American* race, (for this race is called indifferently by all these names,) a *pigmental apparatus*, which is the seat of the *red* or *copper color* of this race, as the *pigmental apparatus* of the negro is the seat of his black color."

Dr. Morton does not advert to the existence of this pigmental apparatus in the American race. The investigations of Dr. McCulloh, he observes, "satisfactorily prove that the designation '*copper-colored*,' is wholly inapplicable to the Americans as a race." "The *cinnamon* is, in Dr. McCulloh's apprehension, the nearest approach to the true color" of the native Americans. Dr. Morton considers that the "*brown race*" most correctly designates them collectively. "Although," says he, "the Americans thus possess a pervading and characteristic complexion, there are occasional and very remarkable deviations, including all the tints from a decided white to an unequivocally black skin." He shows, also, by numerous authorities, that "climate exerts a subordinate agency in producing these diversified hues." The tribes which wander along the burning plains of the equinoctial region, have no darker skins than the mountaineers of the temperate zone. "Again, the Puelchés, and other inhabitants of the Magellanic region, beyond the 55th degree of south latitude, are absolutely darker than the Abipones, Macobios and Tobas, who are many degrees nearer the equator. While the Botocudys are of a clear brown color, and sometimes nearly white, at no great distance from the tropic; and moreover, while the Guyacas, under the line, are characterized by a fair complexion, the Charruas, who are almost black, inhabit the 50th degree of south latitude; and the yet blacker Californians, are 25 degrees north of the equator." "After all," he adds, "these differences in complex-

* Annales des Sciences Nat. t. x, Dec. 1838, pp. 361, &c.

ion are extremely partial, forming mere exceptions to the primitive and national tint that characterizes these people, from Cape Horn to the Canadas. The cause of these anomalies is not readily explained; that it is not climate is sufficiently obvious; and whether it arises from partial immigrations from other countries, remains yet to be decided."

Buffon defines species—"A succession of similar individuals which reproduce each other." Cuvier also defines species—"The union of individuals descended from each other or from common parents, and of those who resemble them as much as they resemble each other." "The apparent differences of the races of our domestic species," says Cuvier, "are stronger than those of any species of the same genus." "The fact of the *succession*, therefore, and of the *constant succession*, constitutes alone *the unity of the species.*" Flourens, who cites these definitions, concludes that "*unity, absolute unity*, of the human species, and *variety* of its races, as a final result, is the general and certain conclusion of all the facts acquired concerning the *natural history of man.*"*

Dr. Morton, while he assumes the unity of the species, conceives that "each race was adapted from the beginning (by an all-wise Providence) to its peculiar local destination. In other words, that the physical characteristics which distinguish the different races, are independent of external causes."

This inference derives support from the fact adverted to by Dr. Caldwell, in his "Thoughts on the Unity of the Human Species." "It is," says he, "4179 years since Noah and his family came out of the ark. They are believed to have been of the Caucasian race." "3445 years ago, a nation of Ethiopians is known to have existed. Their skins, of course, were dark, and they differed widely from the Caucasians in many other particulars. They migrated from a remote country and took up their residence in the neighborhood of Egypt. Supposing that people to have been of the stock of Noah, the change must have been completed, and a new race formed, in 733 years, and probably in a much shorter period."† Dr. Morton observes, that "the recent discoveries in Egypt give additional force to the preceding state-

* Flourens' article before cited, and the Edin. New Philosophic. Journ., Vol. xxvii, p 358, October, 1839.

† P. 72. Phila., 1830.

ment, inasmuch as they show, beyond all question, that the Caucasian and Negro races were as perfectly distinct in that country, upwards of three thousand years ago, as they are now ; whence it is evident, that if the Caucasian was derived from the Negro, or the Negro from the Caucasian, *by the action of external causes*, the change must have been effected in at most one thousand years ; a theory which the subsequent evidence of thirty centuries proves to be a physical impossibility ; and we have already ventured to insist that such a commutation could be effected by nothing short of a miracle." p. 88.

Dr. Morton describes the general characteristics of the American, under the head of the "Varieties of the Human Species," and then enters on a special description of the "crania" of upwards of seventy nations or tribes belonging to that family, illustrating the text by admirable plates of the crania, drawn from skulls, mostly in his own possession, and of the full size of nature.

He regards the American race as possessing certain physical traits that serve to identify them in localities the most remote from each other. There are, also, in their multitudinous languages, the traces of a common origin. He divides the race into the "Toltecan family," which bears evidence of centuries of demi-civilization, and into the "American family," which embraces all the barbarous nations of the new world, excepting the Polar tribes, or Mongol Americans. The Eskimaux, and especially the Greenlanders, are regarded as a partially mixed race, among whom the physical character of the Mongolian predominates, while their language presents obvious analogies to that of the Chippewyans, who border on them to the south.

In the American family itself, there are several subordinate groups. 1st. The *Appalachian* branch includes all the nations of North America, excepting the Mexicans, together with the tribes north of the river of Amazon and east of the Andes. 2d. The *Brazilian* branch is spread over a great part of South America east of the Andes, viz. between the Rivers Amazon and La Plata, and between the Andes and the Atlantic, thus including the whole of Brazil and Paraguay north of the 35th degree of south latitude. In character, these nations are warlike, cruel, and unforgiving. They turn with aversion from the restraints of civilized life, and have made but trifling progress in mental cul-

ture or the useful arts. In character, the Brazilian nations scarcely differ from the Appalachian ; none of the American tribes are less susceptible of cultivation than these ; and what they are taught by compulsion, in the missions, seldom exceeds the humblest elements of knowledge. 3d. The *Patagonian* branch includes the nations south of the La Plata, to the Straits of Magellan, and the mountain tribes of Chili. They are for the most part distinguished for their tall stature, their fine forms, and their indomitable courage, of all which traits the Auracanians possess a conspicuous share. 4th. The *Fuegian* branch, which roves over a sterile waste, computed to be as large as one half of Ireland. Forster computes their whole number at only two thousand souls. Their physical aspect is altogether repulsive, and their domestic usages tend to heighten the defects of nature. The expression of the face is vacant, and their mental operations are to the last degree slow and stupid. The difference between them and the other Americans, is attributed by Dr. Morton to the effects of climate and locality.

Thus far Dr. Morton has travelled over ground previously occupied by other naturalists ; but we proceed to a field in which he has had the courage and sagacity to enter boldly on a new path. He has added to his text numerous and minute measurements of the size and capacity not only of each entire cranium, but of its different parts, with a view to elucidate the connection (if there be any) between particular regions of the brain and particular mental qualities of the American tribes. In his dedication to John S. Phillips, Esq., of Philadelphia,* he observes : " It may, perhaps, be thought by some readers, that these details are unnecessarily minute, especially in the phrenological tables ; and again, others would have preferred a work conducted throughout on phrenological principles. In this study I am yet a learner ; and it appeared to me the wiser plan to present the facts unbiassed by theory, and let the reader draw his own conclusions. You and I have long admitted the fundamental principles of phrenology, viz. that the brain is the organ of the mind, and that its different parts perform different functions ; but we have been

* Dr. Morton acknowledges himself to be under many obligations to Mr. Phillips in the prosecution of his enquiries, and says that it was he who invented the machines used in making the measurements, and executed many of them himself.

slow to acknowledge the details of cranioscopy as taught by Dr. Gall, and supported and extended by subsequent observers. We have not, however, neglected this branch of enquiry, but have endeavored to examine it in connection with numerous facts, which can only be fully appreciated when they come to be compared with similar measurements derived from the other races of men." We shall state, in a subsequent part of this article, the conclusions at which Dr. Morton has arrived, in consequence of his observations and measurements; meantime it is important to state the principles on which he proceeded.

In a few years, it will appear a singular fact in the history of mind, that in the nineteenth century, men holding the eminent station in literature occupied by Lord Jeffrey and Lord Brougham, should have seriously denied* that the mind, in this world, acts by means of material organs; yet such is the case; and the denial can be accounted for only by that entire neglect of physiology, as a branch of general education, which prevailed in the last century, and by the fact that the metaphysical philosophy in which they were instructed, bore no reference to the functions of the brain. We need not say, that no adequately instructed naturalist doubts that the brain is the organ of the mind. But there are two questions, on which great difference of opinion continues to prevail: 1st. Whether the *size* of the brain (health, age, and constitution being equal) has any, and if so, what influence, on the power of mental manifestation? and 2dly. Whether different faculties be, or be not, manifested by particular portions of the brain.

The *first* proposition, that the size of the brain, other conditions being equal, is in direct relation to the power of mental manifestation, is supported by analogy, by several well known facts, and by high physiological authorities. The power of smell, for example, is great in proportion to the expansion of the olfactory nerve on the internal nostrils, and the volume of the nerve itself bears a direct relation to the degree of that expansion. The superficial surface of the mucous membrane of the ethmoidal bone, on which the nerve of smell is ramified, is computed in man to extend to 20 square inches, and in the seal, which has

* Lord Jeffrey, in the Edin. Review, No. 88, and Lord Brougham in his Discourse on Natural Theology, p. 120.

great power of smell, to 120 square inches. The optic nerve in the mole is a slender thread, and its vision is feeble; the same nerve is large and thick in the eagle, accompanied by intense powers of sight. Again, the fact admits of demonstration, that deficiency in the size of the brain is one, although not the only, cause of idiotcy. Although the brain be healthy, if the horizontal circumference of the head, with the muscular integuments, do not exceed thirteen or fourteen inches, idiotcy is the *invariable* consequence. Dr. Voisin states that he made observations on the idiots under his care at the Parisian Hospital of Incurables, and found that in the lowest class of idiots, where the intellectual manifestations were null, the horizontal circumference, taken a little higher than the orbit, varied from eleven to thirteen inches, while the distance from the root of the nose backwards, over the top of the head, to the occipital spine, was only between eight and nine inches; and he found no exception to this fact. If, therefore, extreme defect of size in the brain be invariably accompanied by mental imbecility, it is a legitimate inference that size will influence the power of manifestation through all other gradations of magnitude, always assuming other conditions to be equal.

Physiological authorities are equally explicit on this subject. Magendie says, "the volume of the brain is generally in direct proportion to the capacity of the mind. We ought not to suppose, however, that every man having a large head is necessarily a person of superior intelligence; for there are many causes of an augmentation of the volume of the head besides the size of the brain; but it is rarely found that a man distinguished by his mental faculties has not a large head. The only way of estimating the volume of the brain, in a living person, is to measure the dimensions of the skull; every other means, even that proposed by Camper, is uncertain."

The difference of mental power between young and adult minds, is a matter of common observation. The difference in the weights of their brains is equally decided.

According to Cruveilhier, in three young subjects, the weights of the brains were as follows:

In the first, the brain weighed 2 lbs. 2 oz.; the cerebellum, 4⅛ oz.; together, 2 lbs. 6⅛ oz. In the second, the brain weighed 2 lbs. 8 oz.; the cerebellum, 3½ oz.; together, 2 lbs. 11½ oz. In

the third, the brain weighed 2 lbs. 5 oz.; the cerebellum, 5 oz.; together, 2 lbs. 10 oz.

In the appendix to Dr. Monro's work on the brain, Sir William Hamilton states the average weight of the *adult* male Scotch brain and cerebellum to be 3 lbs. 8 oz. troy.

Again, a difference in mental power between men and women is also generally admitted to exist, and there is a corresponding difference in the size of their brains.

Sir William Hamilton states the average weight of the adult female Scotch brain and cerebellum, to be 3 lbs. 4 oz. troy; being 4 oz. less than that of the male. He found one male brain in *seven* to weigh above 4 lbs.; and only one female brain in a *hundred* exceeded this weight.

In an essay "on the brain of the negro, compared with that of the European and the ourang outang, published in the Philosophical Transactions for 1836, part II, Professor Tiedemann, of Heidelberg, adopts the same principle. After mentioning the weights of fifty-two European brains, examined by himself, he states that "the weight of the brain in an adult male European, varies between 3 lbs. 2 oz. and 4 lbs. 6 oz. troy. The brain of men who have distinguished themselves by their great talents, is often very large. The brain of the celebrated Cuvier weighed 4 lbs. 11 oz. 4 dr. 30 gr. troy, and that of the distinguished surgeon Dupuytren weighed 4 lbs. 10 oz. troy. The brain of men endowed with but feeble intellectual powers is, on the contrary, often very small, particularly in congenital idiotismus. The female brain is lighter than that of the male. It varies between 2 lbs. 8 oz. and 3 lbs. 11 oz. I never found a female brain that weighed 4 lbs. The female brain weighs on an average from four to eight ounces less than that of the male; and this difference is already perceptible in a new-born child."

We have adduced these proofs and authorities in support of the proposition that size influences power, because we conceive it to be a principle of fundamental importance in every investigation into the natural history of man, founded on the physiology of the brain; and also because in the hasty zeal of many of the opponents of phrenology, to undermine the discoveries of Dr. Gall, it has been denied with a boldness and pertinacity more allied to the spirit of contentious disputation, than to that of philosophical enquiry. Its importance in a dissertation on *national crania* is

very apparent. One of the most singular features in the history of this continent, is, that the aboriginal races, with few exceptions, have perished or constantly receded, before the Anglo-Saxon race, and have in no instance either mingled with them as equals, or adopted their manners and civilization. These phenomena must have a cause; and can any enquiry be at once more interesting and philosophical than that which endeavors to ascertain whether that cause be connected with a difference in the brain between the native American race, and their conquering invaders? Farther, some few of the American families, the Auracanian, for instance, have successfully resisted the Europeans; and the question is important, whether in them, the brain be in any respect superior to what it is in the tribes which have unsuccessfully resisted?

It is true, that Dr. Gall's fundamental principle, that size in the brain (other conditions being equal) is a measure of the power of mental manifestation, is directly involved in these enquiries; but we can discover no reason why it should not be put to the test of an extensive and accurate induction of facts. The unphilosophical prejudice that every proposition and fact in physiology must be neglected or opposed, because it bears on the vexed question of phrenology, has been too long indulged. The best interests of science require that it should be laid aside, and we commend Dr. Morton for having resolutely discarded it. He does not enter the field as a partisan, for or against Dr. Gall's doctrines, but as a philosophical enquirer, and states candidly and fearlessly the results of his observations.

Dr. Morton reports the size in cubic inches, of the interior of nearly every skull described by him. "An ingenious mode," says he, "of taking the measurement of the internal capacity, was devised by Mr. Phillips. In order to measure the capacity of a cranium, the foramina were first stopped with cotton, and the cavity was then filled with *white pepper seed*,* poured into the foramen magnum until it reached the surface, and pressed down with the finger until the skull would receive no more. The contents were then transferred to a tin cylinder, which was well shaken in order to pack the seed. A mahogany rod (previously graduated to denote the cubic inches and parts contained in

* "White pepper seed was selected on account of its spherical form, its hardness, and the equal size of the grains. It was also sifted, to render the equality still greater."

the cylinder) being then dropped down, with its foot resting on the seed, the capacity of the cranium, in cubic inches, is at once read off on it."

Dr. Morton gives also measurements of particular regions of the brain, as indicated by the skull; and in this portion of his work, the phrenologists alone can claim precedence of him.

Secondly. The most distinguished philosophers on the mind, divide the human faculties into the active and intellectual powers; and some admit even subdivisions of the feelings into propensities common to man with the lower animals, and moral emotions; and of the intellect, into observing and reflecting faculties. Dr. Thomas Brown's division of the intellectual powers into simple and relative suggestion, corresponds with this last classification. If, then, the mind manifest a plurality of faculties, and if the brain be the organ of the mind, it appears to be a sound inference that the brain *may* consist of a plurality of organs. The presumptions which arise, in favor of this idea, from the constitution of the external senses and their organs, are strong. Each sense has its separate nervous apparatus. Nay, when the function of a part is compound, the nerves are multiplied, so as to give a distinct nerve for each function. The tongue has a nerve for voluntary motion, another for common sensation, and the best authorities admit a third nerve for *taste*, although the precise nerve is still in dispute. The internal nostrils are supplied with two nerves, the olfactory, and a nerve of common sensation, ramified on the mucous membrane, each performing its appropriate function. The spinal marrow consists, by general consent of physiologists, of at least two double columns, the anterior pair for voluntary motion, and the posterior pair for common sensation. Sir Charles Bell has demonstrated the distinct functions of the nerves proceeding from these columns. Farther, every accurate observer distinguishes diversities of disposition and inequalities of talents, even in the same individual. The records of lunatic asylums show numerous instances of partial idiotcy and partial insanity. These facts indicate that the brain consists of a plurality of organs, and this idea is countenanced by many high authorities in physiological science. "The brain is a very complicated organ," says Bonnet, "or rather *an assemblage of very different organs.*"* Tissot contends that every perception has

* Palingénésie, I, 334.

different fibres;* and Haller and Van Swieten were of opinion that the internal senses occupy, in the brain, organs as distinct as the nerves of the external senses.† Cabanis entertained a similar notion,‡ and so did Prochaska. Cuvier says that "*Certain parts* of the brain, in all classes of animals, are *large or small, according to certain qualities of the animals;*"§ and he admits that Gall's doctrine of different faculties being connected with different parts of the brain, is nowise contradictory to the general principles of physiology.‖

If, then, there be reason to believe that different parts of the brain manifest different mental faculties, and if the size of the part influence the power of manifestation, the necessity is very evident of taking into consideration the *relative proportions of the different parts of the brain*, in a physiological enquiry into the connection between the crania of nations and their mental qualities. To illustrate this position, we present exact drawings of two casts from nature; one, figure 1, is the brain of an American Indian; and the other, figure 2, the brain of an European. Both casts bear evidence of compression or flattening out, to some extent, by the pressure of the plaster; but the European brain is the flatter of the two. We have a cast of the entire head of this American Indian, and it corresponds closely with the form of the brain here represented.

It is obvious that the absolute quantity of brain, (although probably a few ounces less in the American,) *might* be the *same in both;* and yet, if different portions manifest different mental powers, the characters of the individuals, and of the nations to which they belonged, (assuming them to be types of the races,) might be exceedingly different. In the American Indian, the anterior lobe, lying between A A and B B is small, and in the European it is large, in proportion to the middle lobe, lying between B B and C C. In the American Indian, the posterior lobe, lying between C and D is much smaller than in the European. In the American, the cerebral convolutions on the anterior lobe and upper surface of the brain, are smaller than in the European.

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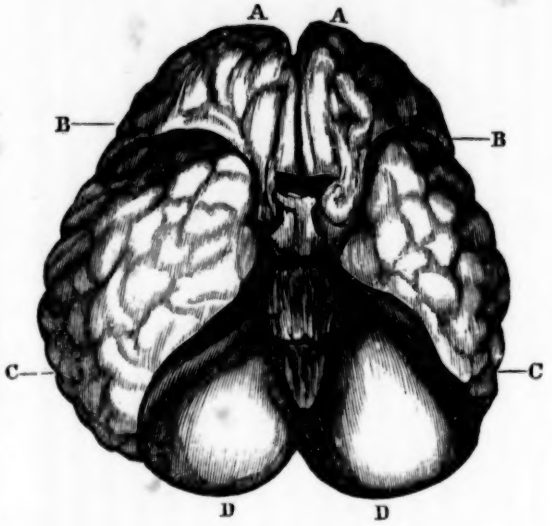
* Œuvres, III, 33. † Van Swieten, I, 454.

‡ Rapports du Physique et du Moral de l'Homme, 2de Edit. I, 233, 4.

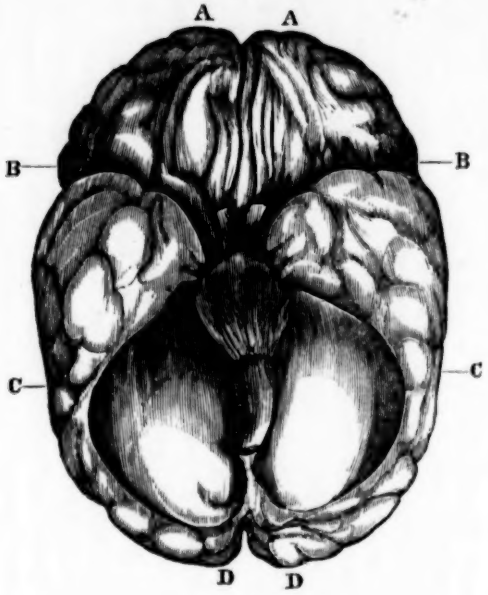
§ Anatomie comparée, tome II.

‖ Rapport Historique sur les Progrès des Sciences Naturelles, &c. p. 193.

American Indian, Fig. 1.



European, Fig. 2.



If the anterior lobe manifest the intellectual faculties—the middle lobe, the propensities common to man with the lower animals—and the posterior lobe, the domestic and social affections; and if size influence power of manifestation—the result will be that in the native American, intellect will be feeble—in the European, strong;—in the American, animal propensity will be very great—in the European, more moderate;—while in the American, the domestic and social affections will be feeble, and in the European, powerful. We do not state these as established results; we use the cuts only to illustrate the fact that the native American and the European brains *differ widely in the proportions of their different parts;** and the conclusion seems natural, that if different functions be attached to different parts, no investigation can deserve attention which does not embrace the size of the different regions, in so far as this can be ascertained.

We have entered more minutely into the reasons why we regard these measurements as important, because we conceive that the distinguishing excellence of Dr. Morton's work consists in his having adopted and followed out this great principle. It appeared necessary to dwell upon it at some length, also, because Professor Tiedemann, in his comparison of the European with the Negro brain, has entirely neglected it, and in consequence has arrived at physiological conclusions which we regard as at variance with the most certain psychological facts, viz. He says that "there is undoubtedly a very close connection between the ABSOLUTE SIZE of the brain and the INTELLECTUAL POWERS AND FUNCTIONS of the mind;" and proceeding on this principle, he compares the weight of the whole brain, as ascertained in upwards of fifty Europeans of different ages and countries, with its weight in several Negroes, examined either by himself or others. He gives extensive tables showing the weight of the quantity of millet seed necessary to fill Ethiopian, Caucasian, Mongolian, American, and Malay skulls; and adds that "the cavity of the skull of the Negro in general, *is not smaller* than that of the European and other human races." The inference which he draws, is that *intellectually* and *morally*, as well as anatomically, the Negro is naturally on a par with the

* From inspecting numerous crania of both races, we cannot doubt of the general truth of this proposition.

European; and he contends that the opposite and popular notion is the result of superficial observation, and is true only of certain degraded tribes on the *coast* of Africa.*

We entertain a great respect for Prof. Tiedemann, but we cannot subscribe to his principle that the whole brain is the measure of the *intellectual* faculties; a proposition which assumes that the animal and moral feelings have no seat in this organ. He does not grapple with Dr. Gall's facts or arguments, but writes as if Gall had never existed. Dr. Morton has followed a different course, and we think wisely. He says, "I was from the beginning, desirous to introduce into this work, a brief chapter on phrenology; but, conscious of my own inability to do justice to the subject, I applied to a professional friend to supply the deficiency. He engaged to do so, and commenced his task with great zeal; but ill health soon obliged him to abandon it, and to seek a distant and more genial climate. Under these circumstances, I resolved to complete the phrenological table, and omit the proposed essay altogether. Early in the present year, however, and just as my work was ready for the press, George Combe, Esq., the distinguished phrenologist, arrived in this country; and I seized the occasion to express my wants to that gentleman, who, with great zeal and promptness, agreed to furnish the desired essay, and actually placed the MS. in my hands before he left the city." He adds that Mr. Combe provided his memoir without having seen a word of the MS. of the work, or even knowing what had been written, and besides, owing to previous arrangements, he was limited to a given number of pages.

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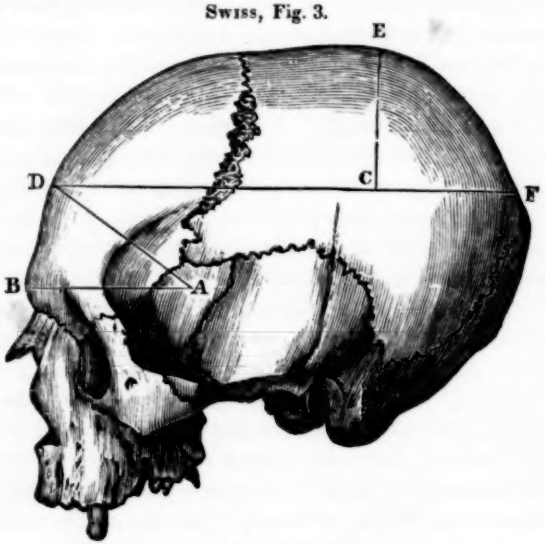
* Tiedemann's Essay has been critically examined by Dr. A. Combe, in the Phrenological Journal, (vol. xi,) who shows not only the error of principle committed by the author in assuming the whole brain to be the organ exclusively of the *intellectual* faculties, but the more striking fact that Tiedemann's own tables refute his own conclusions. Tiedemann's measurements are the following:

	Inches.	Lines.
Average length of brain in 4 Negroes, ...	5	11
do. do. do. 7 European males, . . .	6	2 1-7
do. do. do. 6 European females, . .	5	10½
do. greatest breadth in 4 Negroes, ...	4	8 1 6
do. do. do. 7 European males, . . .	5	1 1-7
do. do. do. 3 European females, . .	5	4½
do. height of brain in 3 Negroes, ...	2	11½
do. do. do. 7 European males, . . .	3	4
do. do. do. 4 European females, . .	2	9½

The inferiority of the Negro brain in size, is self-evident from these dimensions.

We can afford space only to notice Mr. Combe's illustration of the location of the great divisions of the faculties in the different regions of the brain. It is necessary to give this in order to render the true import of several of Dr. Morton's measurements and results intelligible to the reader.

Swiss, Fig. 3.



All the figures are drawn to the same scale.

In this figure (Fig. 3,) a line drawn from the point A transversely across the skull, to the same point on the opposite side, would coincide with the posterior margin of the superorbitary plate: the anterior lobe rests on that plate. The line A B, denotes the length of the anterior lobe from back to front, or the portion of brain lying between A A and B B in figures 1 and 2. A in figure 3, "is located in the middle space between the edge of the suture of the frontal bone and the edge of the squamous suture of the temporal bone, where these approach nearest to each other, on the plane of the super-ciliary ridge." We have examined a Peruvian skull of the Inca race, a skull of a flat-headed Indian, an Indian skull found near Boston, and compared them with several skulls of the Anglo-Saxon race, and observe that the line A B, is considerably longer in the latter than in the former, and that it corresponds with the length of the ante-

rior lobe, as denoted by the super-orbitar plate. The point C is the centre of ossification of the parietal bone, corresponding to the centre of Cautiousness. The line C D is drawn from C through the center of ossification in the left side of the frontal bone. This is the centre of Causality. E corresponds with Firmness of the phrenologist. The space D A B is an approximation to the department occupied by the intellectual faculties. D C E contains the organs of the moral sentiments. All the space behind A and below the line D C F is devoted to the animal organs. The space E C F contains Self-Esteem and Love of Approbation, which may act either with the moral sentiments or animal propensities, according as either predominate. Mr. Combe states that these lines are only approximations to accurate demarcations of the regions, as no modes of rigid admeasurement have yet been discovered.

Mr. Phillips invented an instrument, (which he describes,) by which Dr. Morton and he measured the contents of the space above D C F in cubic inches, in nearly all the skulls. This is called the *coronal region.* By deducting the contents of this space from the contents of the whole skull, they give the measurement of the *subcoronal region.* Mr. Phillips found it impossible to measure D A B and the space behind A and below D C F in cubic inches, and Dr. M. therefore measured, as an approximation, the whole space contained in the skull anterior to the anterior margin of the foramen magnum. He designates this the *anterior chamber.* He measured all behind that margin, and calls it the *posterior chamber.*

In addition to these, Mr. Phillips has added tables of thirty nine phrenological measurements, (which are lucidly described by him,) of each skull. We quote the following statement as an example of the spirit of philosophical enquiry, which animated Mr. Phillips in his labors. "A series of measurements with the craniometer and compasses, much more extensive than any we had seen published, had been carefully made on upwards of ninety of the crania, when Mr. George Combe arrived in this city. That gentleman immediately pointed out so many erroneous points of measurement, (arising from the use of a badly marked bust,) that those tables *were condemned,* together with the labor bestowed on them," and new measurements of the whole were substituted in their place!

It is impossible to commend too highly the zeal and perseverance manifested by both of these gentlemen in their endeavors to do justice to their subject; and we anticipate that their example, and the results to which their labors have led, will give a powerful impulse to others to prosecute this interesting branch of science.

We shall now present a brief view of the manner in which Dr. Morton applies his own principles, and of some of the conclusions at which he has arrived.

He divides the native American nations into two great families, the *Toltecan* and *American*. "It is in the intellectual faculties, says he, that we discover the greatest difference between them. In the arts and sciences of the former we see the evidences of an advanced civilization. From the Rio Gila in California, to the southern extremity of Peru, their architectural remains are every where encountered to surprise the traveller and confound the antiquary; among these are pyramids, temples, grottoes, bas-reliefs and arabesques; while their roads, aqueducts, and fortifications, and the sites of their mining operations, sufficiently attest their attainments in the practical arts of life." p. 84. The desert of Atacama divides the kingdom of Peru from that of Chilé, and is nearly a hundred miles in length. A river, abounding in salt, runs through it. This desert was the favorite sepulchre of the Peruvian nations for successive ages. The climate, salt and sand, dry up the bodies, and the remains of whole generations of the former inhabitants of Peru may now be examined, after the lapse perhaps of thousands of years. Dr. Morton has been enabled to examine nearly one hundred Peruvian crania, and concludes that that country has been, at different times, peopled by two nations of differently formed crania, one of which is perhaps extinct, or at least exists only as blended by adventitious circumstances, in very remote and scattered tribes of the present Indian race. "Of these two families, that which was antecedent to the appearance of the Incas is designated as the *ancient Peruvian*, of which the remains have been found only in Peru, and especially in that division of it now called Bolivia. Their tombs, according to Mr. Pentland, abound on the shores and islands of the great Lake Titicaca, in the inter-alpine valley of the Desaquadera, and in the elevated valleys of the Peruvian Andes, between the latitudes of 14° and 19° 30′ South." Our knowledge of their physical appearance is

derived solely from their tombs. They were not different "from cognate nations in any respect except in the conformation of the head, which is small, greatly elongated, narrow in its whole length, with a very retreating forehead, and possessing more symmetry than is usual in skulls of the American race. The face projects, the upper jaw is thrust forward, and the teeth are inclined outward. The orbits of the eyes are large and rounded, the nasal bones salient, the zygomatic arches expanded; and there is a remarkable simplicity in the sutures that connect the bones of the cranium." p. 97. Dr. Morton presents the following cranium, plate IV of his series, "as an illustrative type of the cranial peculiarities of the people;" and he is of opinion that the form is "natural, unaltered by art."

Ancient Peruvian, Fig. 4.

He gives the following description of this cranium:

"Though the forehead retreats rapidly, there is but little expansion at the sides, and from the face to the occiput, inclusive, there is a narrowness that seems characteristic of the race. The posterior view represents the skull elevated in that region, without any unnatural width at the sides, and the vertical view sufficiently confirms the latter fact.

MEASUREMENTS.*

Longitudinal diameter, ...	7.3	inches.
Parietal do.	5.3	do.
Frontal do.	4.3	do.
Vertical do.	5.3	do.
Inter-mastoid arch, ...	14.	do.
Inter-mastoid line, ...	4.3	do.
Occipito-frontal arch, ...	15.	do.
Horizontal periphery, ...	19.8	do.
Extreme length of head and face,	8.2	do.
Internal capacity, ...	81.5	cubic inches.
Capacity of the anterior chamber,	31.5	do.
Capacity of the posterior chamber,	50.	do.
Capacity of the coronal region,	16.25	do.
Facial angle, ...	73	degrees."

This skull was found by Dr. Ruschenberger, about a mile from the town of Arica, on the south side of the *morro*, a cemetery of the ancient Peruvians. "The surface is covered with sand an inch or two deep, which being removed discovers a stratum of salt, three or four inches in thickness, that spreads all over the hill. The body (to which this head belonged) was placed in a squatting posture, with the knees drawn up and the hands applied to the sides. The whole was enveloped in a coarse, but close fabric, with stripes of red, which has withstood,

* The measurements are thus described by Dr. Morton. The *longitudinal* diameter is taken from the most prominent part of the os frontis to the occiput; the *parietal* diameter from the most distant points of the parietal bones; the *frontal* diameter from the anterior inferior angles of the parietal bones; the *vertical* diameter from the fossa, between the condyles of the occipital bone, to the top of the skull; the *inter-mastoid arch* is measured with a graduated tape, from the point of one mastoid process to the other, over the external tables of the skull; the *inter-mastoid* line is the distance, in a straight line, between the points of the mastoid processes; the *occipito-frontal arch* is measured by a tape over the surface of the cranium, from the posterior margin of the foramen magnum to the suture, which connects the os frontis with the bones of the nose; the *horizontal periphery* is measured by passing a tape around the cranium so as to touch the os frontis immediately above the superciliary ridges, and the most prominent part of the occipital bone; the *length of the head and face* is measured from the margin of the upper jaw, to the most distant point of the occiput; the *zygomatic diameter* is the distance, in a right line, between the most prominent points of the *zygomæ;* the *facial angle* is ascertained by an instrument of ingenious construction and easy application, invented by Dr. Turnpenny, and described by Dr. Morton. Dr. Morton took nearly all the anatomical measurements with his own hands.

wonderfully, the destroying effects of ages, for these interments were made before the conquest, although at what period is unknown."

Dr. Morton states that the average internal capacity of the Caucasian or European head, is at least 90 cubic inches. In three adult ancient Peruvians, it is only 73. The mean capacity of the anterior chamber is about one half of that of the posterior, or 25 to 47, while the mean facial angle is but 67 degrees.

"It would," he continues, "be natural to suppose, that a people with heads so small and badly formed, would occupy the lowest place in the scale of human intelligence. Such, however, was not the case." He considers it ascertained that "civilization existed in Peru anterior to the advent of the Incas, and that those anciently civilized people constituted the identical nations whose extraordinary skulls are the subjects of our present inquiry."

There is a discrepancy between this description of these skulls and the civilization ascribed to their possessors, which is unique in Dr. Morton's work. In every other race, ancient and modern, the coincidence between superior cranial forms and superior mental qualities, is conspicuous. On turning to Mr. Phillips's phrenological measurements, however, we find that the *mean* extent of the forehead in this skull, from the point A on one side, to the same point on the other, over B, or the "inter-sphenoidal arch, over the *perceptive* organs," (as ascertained by a graduated tape,) is 6.37 inches; and the mean extent from A to A, over D, or the "inter-sphenoidal arch over the *reflective* organs," is 6.12 inches. The mean of the same measurements of "100 *unaltered* crania of adult aboriginal Americans," of which many are ascertained to be males, are 6.7 and 6.87 inches; showing a superiority in the region of the *observing organs* in the ancient race, and in that of the *reflecting organs* in the modern. This indicates a larger quantity of brain in the anterior lobe in the extinct race, than Dr. Morton's description leads us to infer. This subject obviously requires further elucidation.

If these skulls had been compressed by art, we could have understood that certain portions of the brain might have been only displaced, but not destroyed. The spine, for instance, may be bent, as in hump-back, yet retain its functions; and we might suppose the anterior lobe, in cases of compression, to be

developed laterally, or backwards, and still preserve its identity and uses. This, indeed, is Dr. Morton's own conclusion, in regard to the brain in the flat-headed Indians. He gives an interesting and authentic description of the instrument and process by means of which the flat-head tribes of Columbia River compress the skull, and remarks that "besides the depression of the head, the face is widened and projected forward by the process, so as materially to diminish the facial angle; the breadth between the parietal bones is greatly augmented, and a striking irregularity of the two sides of the cranium almost invariably follows; yet the absolute internal capacity of the skull is not diminished, and, strange as it may seem, the intellectual faculties suffer nothing. The latter fact is proved by the concurrent testimony of all travellers who have written on the subject." Dr. Morton adds, that in January, 1839, he was gratified with a personal interview with a full blood Chenouk, in Philadelphia. He is named William Brooks, was 20 years of age, had been three years in charge of some Christian missionaries, and had acquired great proficiency in the English language, which he understood and spoke with a good accent and general grammatical accuracy. His head was as much distorted by mechanical compression, as any skull of his tribe in Dr. Morton's possession. "He appeared to me," he adds, "to possess more mental acuteness than any Indian I had seen, was communicative, cheerful, and well mannered." The measurements of his head were these: longitudinal diameter, 7.5 inches; parietal diameter, 6.9 inches; frontal diameter, 6.1 inches; breadth between the cheek bones, 6.1 inches; facial angle, about 73 degrees. Dr. Morton considers it certain that the forms of the skull produced by compression, never become congenital, even in successive generations, but that the characteristic form is always preserved, unless art has directly interfered to distort it. pp. 206, 207.*

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* Mr. George Combe, in his late lectures in New Haven, mentioned, that in May, 1839, he had been introduced, in New York, to the Rev. Jason Lee, who had been a missionary among the Indians, 2000 miles beyond the Rocky Mountains, and who had with him Thomas Adams, a young Indian of about 20 years of age, of the Cloughewallah tribe, located about 25 miles from the Columbia River. This young man's head had been compressed by means of a board and cushions, in infancy. Mr. C. examined his head, and found that the parietal was actually greater than the frontal and occipital diameter. The organs in the superciliary ridge of the forehead were fully developed; the upper part of the forehead was flat and

The extinct race in Peru, was succeeded by the "INCA, OR MODERN PERUVIANS." This race dates its possession of Peru from about the eleventh century of our era; and as this period corresponds with the epoch of the migration from Mexico of the Toltecas, the most civilized nation of ancient Mexico, Dr. Morton concurs in the opinion expressed by other authors, that the modern Peruvians were of a common origin with the ancient Mexicans. "The modern Peruvians," says he, "differ little in person from the Indians around them, being of the middling stature, well limbed, and with small feet and hands. Their faces are round, their eyes small, black, and rather distant from each other; their noses are small, the mouth somewhat large, and the teeth remarkably fine. Their complexion is a dark brown, and their hair long, black, and rather coarse." p. 115. The civilization and comparative refinement of the Incas was blended with some remains of the ferocity of the savage. "Matrimonial engagements were entered into with very little ceremony or forethought, and they were as readily set aside at the option of the parties. Polygamy was lawful, but not prevalent." Among the people, incontinence, sensuality, and child-murder were common. Their diet was chiefly vegetables. The people were indolent, filthy and negligent in their persons. The hair of their mummies, in many instances, is charged with desiccated vermin. Their religious system was marked by great simplicity, and was divested of those bloody rites which were common with the Aztecs of

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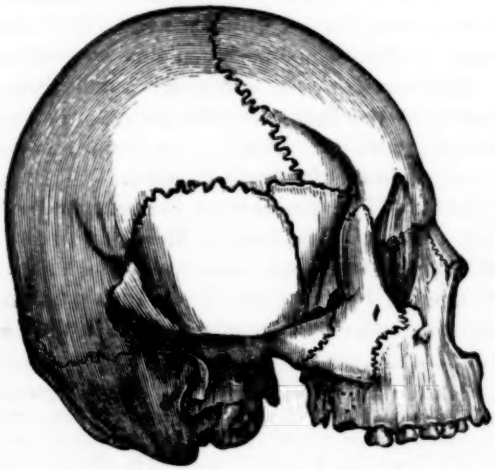
deficient; his organs of language and form, said Mr. C., were large. He had studied the English language for two years, and spoke it tolerably well. Mr. C. added, that in conversation he was intelligent, ready, and fluent, on all subjects that fell within the scope of the faculties of observation, situated in the superciliary ridge, but dull, unintelligent, and destitute equally of ideas and language, on topics that implied the activity of the reflecting faculties, situated in the upper part of the forehead. Mr. C. considered his mental powers to be in direct harmony with the development of his brain. We record this observation, because it is obvious, that if different parts of the brain manifest different faculties, it is indispensable that observations on the *manifestations* of the mental powers should be equally minute and discriminative with those on the development of particular portions of the cranium. Mr. C. added, that the only way to ascertain whether the brain was merely displaced by compression, or otherwise altered, was by careful examination after death; and that he had recommended to Mr. Lee to call the attention of any medical men who might visit these Indians, to this subject. We observed the death of one of these flat-headed Indians mentioned as having occurred in New York. Did any of the phrenologists or anti-phrenologists examine the brain? It was an excellent opportunity for Dr. Rees.

Mexico. They believed in one God, whom they called Viracocha, in the immortality of the soul, and in rewards and punishments in the next life. They worshipped both the sun and moon, in whose honor they erected temples and formed idols. They consecrated virgins, in the same manner as practised in modern convents. Their funeral rites were barbarous and cruel: when their chief men died, they buried a number of human victims, women, boys and servants, to attend on the departed in the next world. They were conquered by Pizarro with a force which consisted of 62 horsemen and 102 foot soldiers. p. 124. The following is given as a strikingly characteristic Peruvian head.

MODERN PERUVIAN, Fig. 5.



"The skull in these people," says Dr. Morton, "is remarkable for its small size, and for its quadrangular form. The occiput is greatly compressed, sometimes absolutely vertical; the sides are swelled out, and the forehead is somewhat elevated, but very retreating. The skulls are remarkable for their irregularity. The dimensions of this skull are as follows:

Longitudinal diameter, ...	6.1	inches.
Parietal do.	6.	do.
Frontal diameter, ...	4.7	do.
Vertical do.	5.5	do.

Inter-mastoid arch,	16.	inches.
Inter-mastoid line,	4.5	do.
Occipito-frontal arch,	14.1	do.
Horizontal periphery,	19.5	do.
Internal capacity,	83.	cubic inches.
Capacity of the anterior chamber,	33.5	do.
Capacity of the posterior chamber,	49.5	do.
Capacity of the coronal region,	15.75	do.
Facial angle,	81	degrees."

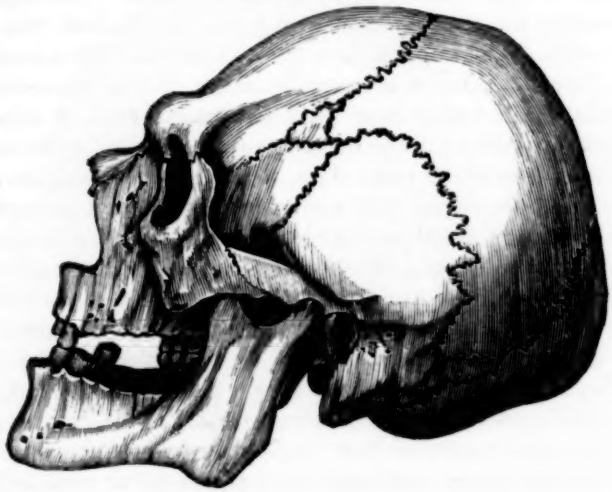
Dr. Morton gives the result of the measurement of twenty-three adult skulls of the pure Inca race. "The mean of the internal capacity is 73 cubic inches, which is probably lower than that of any other people now existing, not excepting the Hindoos." The mean of the anterior chamber is 32, of the posterior, 42, of the coronal region, 12 cubic inches. The highest measure of the coronal region is 20.5, and the smallest 9.25 cubic inches. The mean facial angle is 75 degrees. The heads of nine Peruvian children appear to be nearly, if not quite as large, as those of children of other nations at the same age. p. 133.

The small size of the brains of this race, compared with that of the Europeans who invaded them, is in accordance with the ease with which the former were overcome and retained in subjection. The deficiency in the posterior region of the brain, in which the organs of the domestic affections are situated, corresponds with their feeble conjugal attachment and indifference to the lives of their children. The diameter from constructiveness to constructiveness, is stated by Mr. Phillips to be 4.5 inches, and from ideality to ideality, 5.1. These organs give a talent for art, and are considerable. The same measurements in the Naumkeagh, the race which occupied New England, and whose skulls are still dug up near Boston and Salem, and which never made any attainments in the arts, are 4.1 and 4 inches, respectively. Dr. Robertson, in his history of America, mentions that the modern Peruvian race was distinguished for its extraordinary powers of concealment and secrecy. Mr. Phillips states the breadth from secretiveness to secretiveness to be 5.6 inches, which is large; the longitudinal diameter is only 6.1. The region of combativeness also appears to be deficient in these skulls.

The Iroquois confederacy, consisted originally of five nations, the Mohawks, Oneidas, Onondagas, Cayugas and Senecas. They

were intellectually superior to the surrounding nations, passionately devoted to war, and victorious over the other tribes. They forced their women to work in the field and carry burdens; they paid little respect to old age, were not much affected by love, were regardless of connubial obligations, and addicted to suicide. "They were proud, audacious, and vindictive, untiring in the pursuit of an enemy, and remorseless in the gratification of their revenge. Their religious ideas were vague, and their cautiousness and cunning proverbial. They were finally subdued and nearly exterminated by the Anglo-Americans in 1779. Some miserable remnants of them, ruined by intoxicating liquors, still exist in the state of New York." The following is the skull of a Huron, one of these nations.

Huron, Fig. 6.

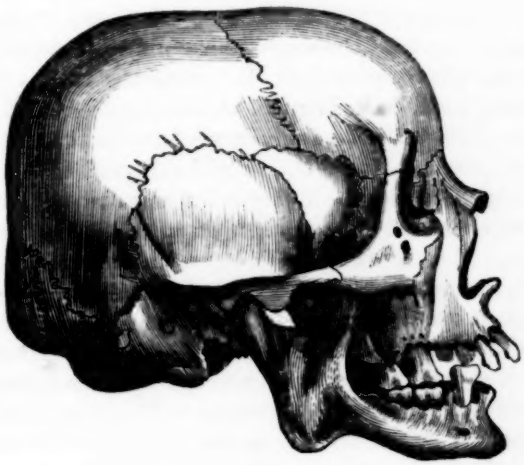


The following are *average* measurements of the five skulls of these nations given by Dr. Morton: internal capacity, 88; coronal region, 15; anterior chamber, 31.5; posterior chamber, 50 cubic inches.

The Araucanians are the most celebrated and powerful of the Chilian tribes. They inhabit the region between the rivers Biobio and Valdivia, and between the Andes and the sea, and derive their name from the province of Arauco. "They are a robust

and muscular people, of a lighter complexion than the surrounding tribes. Endowed with an extraordinary degree of bodily activity, they reach old age with few infirmities, and, generally, retain their sight, teeth, and memory, unimpaired. They are brave, discreet, and cunning to a proverb, patient in fatigue, enthusiastic in all their enterprises, and fond of war as the only source of distinction." "Their vigilance soon detected the value of the military discipline of the Spaniards, and especially the great importance of cavalry in an army; and they lost no time in adopting both these resources, to the dismay and discomfiture of their enemies. Thus in seventeen years after their first encounter with Europeans, they possessed several strong squadrons of horse, conducted their operations in military order, and, unlike the Americans generally, met their enemies in the open field." "They are highly susceptible of mental culture, but they despise the restraints of civilization, and those of them who have been educated in the Spanish colonies, have embraced the first opportunity to resume the haunts and habits of their nation." p. 241. The following is one of three Araucanian skulls delineated in the work.

ARAUCANIAN, Fig. 7.



The average measurements of the three skulls are as follows: internal capacity, 79; coronal region, 15.4; anterior chamber 32.2; posterior chamber, 48.50.

The measurements of the *anterior* and *posterior* chambers, as we have already mentioned, (p. 359,) are not in accordance with any phrenological rule. The anterior embraces the whole intellect, a portion of the moral sentiments, and a portion of the animal propensities; while the posterior chamber includes the remainder of the animal propensities and the remainder of the moral organs. The measurement of the internal capacity, is free from all objection; and that of the coronal region approaches to correctness; but the first gives merely the aggregate size of all the organs, animal, moral, and intellectual; and the second that of the moral organs, with a portion of the intellectual organs, and also a portion of the organs common to man with the lower animals. The phrenological measurements given by Mr. Phillips may probably afford more correct means of comparing one portion of the brain with another, in the different nations, but our limits prevent us from analyzing them. Unfortunately also the letter-press titles to his columns are printed up-side down, which renders it exceedingly laborious to consult them. We, therefore, only remark that the application of lines delineated by Mr. Combe on the skull Figure 1, to those specimens, brings out the relation between the mental character and cranial development pretty forcibly to the eye. Estimating from A to B and D, the ancient Peruvian is seen not to be so defective in the intellectual region as a cursory glance would indicate; while the modern Peruvian is obviously larger in that region. The space above D C, devoted to the moral organs, is large in the mordern Peruvian in proportion to the portion below C D, and behind the ear. This race was intelligent, and comparatively mild, but superstitious and feeble. It has been subdued by the Europeans, and lives under their dominion. The Hurons, always averse to civilization, have been nearly exterminated. The preponderance of the region below C D, (that of the animal propensities,) in them is conspicuous, combined with relative deficiency in the moral and intellectual regions. The Araucanians have maintained their independence in the open field, but resisted civilization. The large development of the space A B C, devoted to intellect, and also that below C D and behind the ear, devoted to the propensities, is obvious, while the space above C D, or the region of the moral organs, is proportionally deficient. This indicates great animal and intellectual power, with imperfectly evolved moral feelings. To the latter

defect, probably is to be ascribed their aversion to civilized habits. The inferiority of all of these skulls to that of the Swiss is conspicuous. The internal capacity of it is 95.5, and that of the coronal region, 21.25. Dr. Morton does not give the capacity of the anterior and posterior chambers of this skull, but the larger dimensions of the intellectual organs have already been stated.

We have no space to enter into any description of the skulls found in the ancient tombs, or of those of the Flat-headed Indians and Charibs; suffice it to say that Dr. Morton's materials are full and satisfactory on these topics, and his facts and conclusions highly interesting. We subjoin a few of the general results at which he arrives from a survey of his entire field.

"The intellectual faculties," says he, "of the great AMERICAN FAMILY, appear to be of a decidedly inferior cast, when compared with those of the Caucasian or Mongolian races. They are not only averse to the restraints of education, but for the most part incapable of a continued process of reasoning on abstract subjects. Their minds seize with avidity on simple truths, while they at once reject whatever requires investigation and analysis. Their proximity, for more than two centuries, to European institutions, has made scarcely any appreciable change in their mode of thinking or their manner of life; and as to their own social condition, they are probably in most respects what they were at the primitive epoch of their existence. They have made few or no improvements in building their houses or their boats; their inventive and imitative faculties appear to be of a very humble grade, nor have they the smallest predilection for the arts or sciences. The long annals of missionary labor and private benefaction bestowed upon them, offer but very few exceptions to the preceding statement, which, on the contrary, is sustained by the combined testimony of almost all practical observers. Even in cases where they have received an ample education, and have remained for many years in civilized society, they lose none of their innate love of their own national usages, which they have almost invariably resumed when chance has left them to choose for themselves." "However much the benevolent mind may regret the inaptitude of the Indians for civilization, the affirmative of this question seems to be established beyond a doubt. His moral and physical nature are alike adapted to his position among the races of men, and it is as reasonable to expect the one to be changed

as the other. The structure of his mind appears to be different from that of the white man, nor can the two harmonize in their social relations except on the most limited scale. Every one knows, however, that the mind expands by culture; nor can we yet tell how near the Indian would approach the Caucasian after education had been bestowed on a single family through several successive generations." p. 82.*

The following are parts of Dr. Morton's table of "mean results," given from his whole measurements.

	Toltecan nations, and skulls from mounds.		Barbarous nations, with skulls from the valley of Ohio.		American race, embracing Toltecan and barbarous nations.		Flathead tribe of Columbia river.		Ancient Peruvians.	
	No. of skulls.	Mean.	No. of skulls.	Mean.	No. of skulls.	Mean.	No. of skulls.	Mean.	No. of skulls	Mean.
Internal capacity in cubic inches,	57	76.8	87	82.4	144	79.6	8	79.25	3	73.2
Capacity of anterior chamber,	46	32.5	73	34.5	119	33.5	8	32.25	3	25.7
Capacity of posterior chamber,	46	43.8	73	48.6	119	46.2	8	47.00	3	47.4
Capacity of coronal region,	46	14.0	71	16.2	117	15.1	8	11.09	3	14.6
Capacity of sub-coronal region,	46	61.8	71	66.5	117	64.5	8	67.35	3	58.6

Remarks.—"The barbarous nations possess a larger brain by 5½ cubic inches, than the Toltecans; while, on the other hand, the Toltecans possess a greater relative capacity of the anterior chamber of the skull, in the proportion of 42.3 to 41.8. Again, the coronal region, though absolutely greater in the barbarous tribes, is rather larger in proportion in the demi-civilized tribes; and the facial angle is much the same in both, and may be assumed, for the race, at 75 degrees.

"In conclusion, the author is of the opinion that the facts contained in this work tend to sustain the following propositions:

"1st. That the American race differs essentially from all others, not excepting the Mongolians; nor do the feeble analogies of language, and the more obvious ones, in civil and religious institutions and the arts, denote any thing beyond casual or colonial communication with the Asiatic nations; and even those analogies may perhaps be accounted for, as Humboldt has suggested, in the mere coincidence arising from similar wants and impulses in nations inhabiting similar latitudes.

* Dr. Morton adds that the Indians are extremely defective in comprehending every thing relating to numbers, and we may remark that Mr. Combe, in his lectures in New Haven, showed the great deficiency of the organ of number in their skulls.

"2d. That the American nations, excepting the polar tribes, are of one race and one species, but of two great families, which resemble each other in physical, but differ in intellectual character.

"3d. That the cranial remains discovered in the mounds from Peru to Wisconsin, belong to the same race, and probably to the Toltecan family." Dr. Morton subjoins the following

"NOTE *on the internal capacity of the cranium in the different races of men.* Having subjected the skulls in my possession, and such also as I could obtain from my friends, to the internal capacity measurement already described, I have obtained the following results. The mean of the American race (omitting fractions) is repeated here, merely to complete the table. The skulls of idiots, and persons under age, were of course rejected.

Races.	No. of skulls.	Mean internal capacity in cubic inch.	Largest in the series.	Smallest in the series.
1. Caucasian,	52	87	109	75
2. Mongolian,	10	83	93	69
3. Malay,	18	81	89	64
4. American,	147	80	100	60
5. Ethiopian,	29	78	94	65

"1st. The *Caucasians* were, with a single exception, derived from the lowest and least educated class of society. It is proper, however, to mention that but three Hindoos are admitted in the whole number, because the skulls of these people are probably smaller than those of any other existing nation. For example, seventeen Hindoo heads give a mean of but seventy-five cubic inches; and the three received into the table are taken at that average. To be more specific, we will give, in detail, the number of individuals of each nation, as far as ascertained.

Anglo-Americans, ...	6
German, Swiss and Dutch, ...	7
Celtic, Irish and Scots, ...	7
English, ...	4
Guanché, (Lybian,)	1
Spanish, ...	1
Hindoo, ...	3
Europeans not ascertained, ...	23
Total, ...	52

"2d. The *Mongolians* measured, consist of Chinese and Eskimaux, and what is worthy of remark, three of the latter give a mean of 86 cubic inches, while seven Chinese give but 82.

"3d. The Malays embrace Malays proper and Polynesians, thirteen of the former and five of the latter; and the mean of each presents but a fractional difference from the mean of all.

"4th. The *Ethiopians* were all unmixed negroes, and nine of them native Africans, for which I am chiefly indebted to Dr. McDowell, formerly attached to the colony at Liberia.*

"5th. Respecting the American race, I have nothing to add, excepting the striking fact that of all the American nations, the Peruvians had the smallest heads, while those of the Mexicans were something larger, and those of the barbarous tribes the largest of all, viz.

Toltecan nations,	Peruvians collectively,	76	cub. inch.
	Mexicans collectively,	79	do.
	Barbarous tribes, as per table,	82	do.

"An interesting question remains to be solved, viz. the relative proportion of brain in the anterior and posterior chambers of the skull in the different races; an inquiry for which I have hitherto possessed neither sufficient leisure nor adequate materials." p. 261.

We now add Dr. Morton's statement in his prefatory letter to Mr. Phillips. "I am free to acknowledge," says he, "that there is a singular harmony between the mental character of the Indian, and his cranial developments, as explained by phrenology."

Our readers will discover in the length and minuteness of this article, the great value which we attach to Dr. Morton's work. We regard it as an honor to the country, and as a proof of talent, patience, and research in himself, which place him in the first rank among natural philosophers. We rejoice to see that he does "not, even now, consider his task as wholly completed;" but hopes to publish a "supplementary volume, in which it will fur-

* Dr. Morton states the mean internal capacity of the European, or Caucasian skulls, to be 87, and of the Ethiopian, or Negro race, to be 78 cubic inches. We observe that Dr. Andrew Combe, in his "Remarks on the Fallacy of Professor Tiedemann's Comparison of the Negro brain and intellect with those of the European," arrives at results coinciding with those obtained by Dr. Morton. Tiedemann gives the weight of only four Negro brains. "The average European," he says, "runs from 3 lbs. 2 oz. to 4 lbs. 6 oz.; while the average of the four Negro brains rises to only 3 lbs. 5 oz. 1 dr.; or 3 oz. above the lowest European averages; and the *highest* Negro falls 5 oz. short of the highest *average* European, and no less than 10 oz. short of Cuvier's brain." Phren. Journ., Vol. XI. We have already shown, p. 357, that Tiedemann's linear dimensions of the European and Negro brain also contradict his theory of equality, and are in harmony with Dr. Morton's results.

ther be my aim to extend and revise both the anatomical and phrenological tables, and to give basal views of at least a part of the crania delineated." We sincerely trust that the favorable reception of this volume will induce him to execute these intentions. Valuable as the materials are in the present work, they lie very much apart. He wrote without systematic relation to phrenology; yet phrenological facts and inferences are presented *passim* throughout the work. Mr. Phillips's phrenological tables are extensive, minute and interesting, but they are not connected directly with the text; while Mr. Combe's essay was composed and printed without his having seen either the text of Dr. Morton, or the final results of Mr. Phillips's measurements. There is strong evidence, in this course of proceeding, of a very direct love of truth, and a reliance on all its parts harmonizing with each other; but much of the effect and instruction are lost to the reader, in consequence of the facts and principles not being brought into juxtaposition by the respective contributors. We shall expect this defect to be supplied in the next edition, which we do not doubt will be called for. The work is remarkably cheap, keeping in view the quantity and quality of the *materiel* of which it is composed.*

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* *Postscript.*—On page 363, we remarked that "there is a discrepancy between the description of the ancient Peruvian skulls, and the civilization ascribed to their possessors, which is unique in Dr. Morton's work." When the present sheet was in the press, we received a letter from Dr. Morton, in which he says, "Since that part of my work which relates to the *ancient Peruvians* was written, I have seen several aditional casts of skulls belonging to the same series, and although I am satisfied that Plate IV, (Fig. 4, p. 361,) represents an unaltered cranium, yet, as it is the *only unaltered one* I have met with, among the remains of that ancient people, I wish to correct the statement, too hastily drawn, that it is *the cranial type* of their nation. My matured opinion is, that the ancient Peruvians were a branch of the great Toltecan family, and that the cranium had the same general characteristics in both. I am at a loss to conjecture how they *narrowed the face* in such due proportion to the head; but the fact seems indisputable. I shall use every exertion to obtain additional materials for the farther illustration of this subject."

Signed, SAMUEL GEORGE MORTON.

Philadelphia, March 3, 1840.

Dr. Morton requests us also to subjoin the following note: "The author has published five hundred copies of his work, which he nominally divides into two editions, the American and the Foreign. They differ in nothing but the dedication; the American copies being dedicated to Dr. Ruschenberger and Mr. J. S. Phillips—the Foreign copies to Dr. Prichard and James Morton, Esq., the author's uncle. In the Foreign copies, the letter to Mr. Phillips is inserted at the end of the volume."

MISCELLANIES.

DOMESTIC AND FOREIGN.

1. *Aurora Borealis of September* 3, 1839.—The following extracts from observations made at *Middlebury, Vt.*, by Prof. A. C. Twining, (and published in the *People's Press*, Sept. 10, 1839,) were intended for insertion among other accounts at p. 261, but they were unavoidably omitted.

At 7h. 23m. P. M.—daylight being yet strong enough for ordinary purposes of vision—an irregular belt of thin whitish clouds was seen over head, lying east and west; its constituent strata manifesting a tendency to arrange themselves in lines directed towards the magnetic pole, through which the southern boundary of the belt passed, leaving the hemisphere south of the pole unclouded. By attentive observation, some of the clouds were seen to vanish so suddenly as to make it evident that the belt was auroral in its nature. Rosy tints were also just discernible in the N. E. and N. W.; and soon after in the N., faint streamers of light. The belt might probably have been seen earlier if my attention had been directed to it. As daylight departed, the phenomena became more decided. At 7h. 33m. a corona was discernible at the magnetic pole. The belt moved south—rapidly at first—then, to appearance, more slowly, and at last almost imperceptibly; the streaks which composed it blending their light, as they became more distant, till at 7h. 43m. they formed a twilight in the south, having a southern or lower boundary in the form of an arch, whose crown was elevated 10°, and beneath which arch the sky was clear, and dark by contrast, as often seen in the north.

Various evolutions of the aurora presented themselves from this until 9h. 5m. when the arrangement was beautifully symmetrical. A broad, fan-like sheet, having its vertex at the corona, and opening towards the horizon, seemed to be let down over the southern quarter from E. to W., presenting an assemblage of white, yellow, and red streamers, indescribably grand. The corona also was perfect, and exhibited all around a fine striated and mottled appearance, like the most delicately figured fancy-work. From 9h. 21m. to 9h. 23m. the aspects were of such glory and beauty as to excite transports of admiration. I have witnessed all the remarkable auroras of the last five years, in the latitude of New Haven, Conn., but this, for the time just specified, as least doubled in splendor the finest of them all. * * * At 9h. 31m. the aurora was comparatively faint, but embraced the entire concave;—streamers ascending from every side towards and up to the corona, like the rafters of a dome. Just at this moment

appeared for the first time, *auroral waves* or the *merry dancers.** These were very decided and magnificent, and continued their play with various degrees of activity,—all other phenomena seeming to give place to them, until 11h. 10m., at which time the aurora had entirely disappeared except a faint zone of twilight from E. to W. * * * At 1h. 23m. (A. M. 4th) the auroral waves were extremely active; and luminous currents were seen ascending to the corona, distinct from the waves or flashes, and making directly up in the course of the streamers. This was to me an entirely new phenomenon. There was in fact a combination of three phenomena. 1st. The *streamers*, which formed the dome, and seemed to be fixed. 2d. These seemed to be the conductors of a *subtle but just discernible fluid*, which ascended along or beneath them. 3d. This subtle ascending fluid seemed like a medium in which the auroral waves exhibited themselves. This is a description of *appearances* only. It seemed to the spectator as if he was looking up the cupola or funnel of a furnace along which heated vapors were ascending with a rush like that of a mill-race; the vapors being every where pervaded by the flashes and flickerings of the auroral waves. Both the waves and the upward currents were most active as they approached the region of the corona, and were not discernible below about 20° of altitude. At 2h. 10m. I found the waves and all the phenomena faint. The watchman at the cotton manufactory states, however, that near this time there was a period of extreme splendor continuing about two minutes.

2. *Meteoric Observations in November and December*, 1839.—At the time of the expected appearance of an unusual frequency of meteors on the 14th of November, 1839, the sky in this region was so much obscured by clouds, that it could not be determined whether or not there was any uncommon meteoric display. Clouds prevented observation here also on the evenings of the 5th, 6th, and 7th of December, 1839. No accounts have reached us of observations at these dates in places where the sky was clear.

Observations for meteors were made here on the evening of October 8, 1839, and on the mornings (between 3h. 30m. and 5h. A. M.) of October 9, 11, 16, but no unusual meteoric frequency was detected. The general radiation of the meteors was then from the region of the constellation Gemini. (See this Journal, Vol. xxxv, p. 366.)

No intelligence has yet arrived here concerning the result of meteoric observations at the August epoch in southern latitudes. It would not

* It is probable that they were seen simultaneously at Middlebury and at New Haven, (see p. 260,) the time being uncertain within three or four minutes.

be surprising if it should be found that this display is chiefly limited to the northern hemisphere. The inhabitants of the southern hemisphere may, however, at other seasons, be favored with meteoric displays which are to us invisible. E. C. H.

New Haven, Conn.

3. *New edition of* EATON's *Manual of Botany.*—The eighth edition of this popular Manual will be published in the course of the spring of 1840, by Mr. Elias Gates, bookseller, Troy, N. Y. The title in full, is *North American Botany; comprising the Native and Common Cultivated Plants North of Mexico: Genera arranged according to the Artificial and Natural Methods.* In this edition, Prof. Eaton is associated with JOHN WRIGHT, M. D., Prof. Veg. and An. Phys. in Rensselaer Institute; Mem. Yale Nat. Hist. Soc., &c., from whose labors the public may justly expect that the book will receive much increase of value. It will contain indications of the *medicinal properties of plants*, from Lindley's Medical Flora; with numerous other valuable additions and improvements, and will constitute a volume of about 550 pages, large 8vo.

4. *Experimental Researches in Electricity;* by MICHAEL FARADAY, D. C. L., F. R. S. *Reprinted from the Philosophical Transactions of* 1831–1838. London: R. & J. E. Taylor, 1839. 8vo. pp. 574. 8 plates.—This volume comprises the fourteen series of Experimental Researches which this distinguished author has published in the Philosophical Transactions, and which are now reprinted in order to supply the series, accompanied with an Index, in a convenient form, for a moderate price. These Researches have contributed greatly to the advancement of the science of Electricity, and are too well known and appreciated to need any commendation at our hands.

5. *A New Comet.*—At 28 minutes after 3h. A. M., December 9, 1839, (civil reckoning at Berlin,) a new comet was observed by *Encke*, at the Royal Observatory at Berlin, Prussia, at which time he found its right ascension to be 13h. 42m. 44s.; and its southern declination, 11′ 30″.

At 6h. 31m. 13s. A. M., December 10, (civil reckoning at Altona,) Professor *Schumacher*, at the Observatory of Altona, determined the comet's place to be in R. A. 13h. 43m. 45s.; N. Dec. 8′ 18″; at 6h. 2m. 42s. A. M. of the 11th, according to the same observer, the comet's place was in R. A. 13h. 53m. 19.27s.; N. Dec. 27′ 57.7″.

At the Observatory of Hamburg, December 15, at 4h. 21m. 55.38s. A. M. (civil reckoning at Hamburg,) M. *Rümker* found the place of the comet to be in R. A. 14h. 32m. 59.49s.; N. Dec. 1° 39′ 33.49″.—*Extract in N. Y. Jour. of Com. Feb.* 1, 1840.

6. *Reports on the Fishes, Reptiles and Birds of Massachusetts. Published agreeably to an order of the Legislature, by the Commissioners on the Zoological and Botanical Survey of the State.* Boston. 8vo. pp. 426. 4 plates.—This volume, prepared under the fostering care of the enlightened and liberal State of Massachusetts, is a most valuable contribution to science. The first and second reports are drawn up by D. H. Storer, M. D.; the third (on the Birds) by Mr. W. B. O. Peabody. The report on the Fishes is by far the best treatise on this department which has been published in our country. That on the Reptiles, being prepared at short notice and under several disadvantages, is probably less complete than it may hereafter be rendered; but it is nevertheless a work of which the author has no reason to be ashamed. The birds of our country having been so thoroughly described by Wilson, Bonaparte, Audubon, Nuttall, and others, Mr. Peabody considered it unnecessary to copy at length their scientific descriptions, and has therefore very properly given especial attention to an account of their habits. The remarks upon these reports, by a committee of the Boston Nat. Hist. Society, (published at p. 393,) render it unnecessary for us to say any thing more in their praise.

7. *Telescopes.*

To the Editors—Agreeably to your request, I forward you a description of my telescope, with many thanks for your kind offer.

It is fitted up in very handsome style, near 8 feet long and 5 in diameter, objective treble glass, with a magnifying power of about 180; price, $4,000.

In 1821, while at Warsaw, the Emperor Alexander ordered me to make a telescope for his college, such as the one I have now finished, but could not undertake it in consequence of the difficulty of obtaining a suitable piece of flint glass. In travelling through England and France, I met with a piece which enabled me to finish one of the above power, and which I am confident will give satisfaction to men of science.

I have one in hand, of much larger dimensions, viz. 16 or 18 feet long, and 12 or 14 inches diameter, objective glass, but from want of means, cannot proceed with it.

If any society here would advance me $1,000 on the above instrument, they might use it, and I then could proceed with the larger one.

I have to lose a great deal of time in sending to England and France for flint to grind here, but have some now on the way.

I have encouraged the glass manufacturers in this country to make flint glass, and I hope, ere long, to be enabled to get it here instead of having to send to Europe.

Should you visit New York soon, you would honor me much by calling upon me, and I then could explain myself more fully. May I beg the favor of your sending me that number of the American Journal in which the description of the telescope will appear. With very many thanks for the trouble I have occasioned you,

I remain your obedient servant, LEON LEWENBERG.

New York, 28th Feb., 1840.

8. *Interesting Minerals.*—The subscriber has recently supplied himself with an additional collection of the interesting minerals of Nova Scotia, formerly discovered by Dr. Jackson and himself, and is desirous of exchanging them for those of other regions, foreign or domestic. The minerals are similar to those found in the trap rocks of other countries, and the specimens have been selected with great care, are of good size, and most of them beautifully crystallized, often uniting in the same mass, several different species.* Those who may wish to exchange for them specimens of an equivalent character, will please forward to the subscriber a list from which he may make a selection; his object being to obtain those from localities with which his cabinet is not already supplied, without adding much to his stock of duplicates. The minerals comprise most of the species of the genus Kouphone spar of Mohs and Haidinger, besides most of the varieties of rhombohedral and uncleavable quartz, with several interesting ores of iron and copper, crystallizations of carbonate and sulphate of lime, &c. &c. FRANCIS ALGER.

Boston, January 1, 1840.

9. *Observations Météorologiques et Magnétiques faites dans l'étendue de l'Empire de Russie redigées et publiées aux frais du Gouvernement, par* A. T. KUPFFER, Mem. Acad. Sci. St. Pet. Tome 1er. St. Pétersbourg, 1837. 4to. pp. xlvi and 196.—We have been favored by the author with the first volume of this valuable work. It contains, 1st. Extracts from the instructions given to the officers of the mines, appointed to make meteorological and magnetical observations in the Russian Empire, and 2d. Series of tables of observations in meteorology and in magnetism, made at St. Petersburgh and at Catherinenburg, in 1835, 1836. The meteorological observations were taken eight times per diem, and appear to have been made with very great care.

* For an enumeration of these minerals, the reader is referred to Vols. XIV and XV of this Journal, and to the Memoirs of the American Academy, for 1833, new series. Having recently inspected them in Mr. Alger's cabinet, we can bear testimony to their extraordinary beauty and perfection.—EDS.

At Catherinenburg, from the observations made every day of December, 1836, by *M. Reinke*, the magnetic declination was found to be 5° 5′ 23″ east. At the close of the volume is a series of corresponding observations made at St. Petersburgh, on the horary variations of the magnetic declination, during various days in 1835 and 1836. The observations were generally made at intervals of five minutes throughout the entire twenty-four hours. Observations of this nature are now regularly made in various parts of the world, and will soon be greatly extended, through the zeal and liberality of the British nation. We trust that the series, of which the volume before us is so excellent a beginning, will be long continued, and that it may excite the honorable rivalry of all civilized nations to take part in so important a scientific enterprise.

A recent letter from Sir John Herschel to his distinguished correspondent in Boston, expresses an earnest wish that magnetic observations may be extended as far as possible on this vast continent. In anticipation of this view, the American Philosophical Society of Philadelphia had already addressed the Secretary of War on the subject—(we trust with success)—and we believe we are correct in stating, that the Girard College of Philadelphia has appropriated funds for the establishment of a magnetic observatory in connection with that institution.—Eds.

10. *On the geognostic position of the Zeuglodon, or Basilosaurus of Harlan.*—European geologists, whose attention has been directed to the remains of this gigantic animal, seem at a loss to refer it to its position in the scale of formations. If they mean the European formation, of which the American is the equivalent or contemporaneous deposit, I am not surprised at their uncertainty, since the limestone, which abounds in the remains of the Zeuglodon, contains a group of fossils which have scarcely any analogy to those of any European formation. But the position of the Zeuglodon in the scale of American formations is well ascertained, no less than the remains of nine individuals having been found in the limestone of Alabama, immediately under the lower tertiary fossiliferous strata, with which the limestone contains a few species of shells in common. This formation seems to fill the chasm which in Europe has been often noticed to occur between the secondary and tertiary series, or the Maestricht deposit and the eocene, and has been termed by Dr. Morton, "the upper cretaceous formation." It contains very few species in common either with the middle cretaceous strata below, or the lower tertiary above, and might with equal propriety be considered the last of the cretaceous, or the first of the tertiary series. Dr. Harlan has

referred them to the tertiary because they were covered by the eocene fossiliferous sands; but the bones were found on the shore of the Washita River, where the debris of the tertiary has enveloped them, and led to the mistake. I traversed the section of Alabama where the Zeuglodon occurs, and collected the organic remains of the limestone which contains the bones, and therefore I can say without hesitation or doubt, that the gigantic animal is restricted to this limestone, the vertebræ of the different specimens lying in a relative position to each other that could only occur where an animal has remained undisturbed upon the spot where it died. T. A. Conrad.

11. *Professor Johnson's Analyses of Anthracite and Iron Ore.*—In the Journal of the Franklin Institute, November, 1839, is a valuable paper by Prof. Walter R. Johnson, Prof. Chem. and Nat. Phil. Med. Dept. Penn. Coll., entitled—*Analysis of some of the Anthracites and Iron Ores found on the head waters of Beaver Creek, in the Counties of Luzerne, Northampton and Schuylkill, Pa.* The paper contains an account of the geological arrangement of the coal fields lying near the head waters of the Beaver Creek, which were explored by Prof. J. in the summer of 1838, and from which the specimens analyzed were obtained. From the cutting made for the railroad leading to the mines of the Beaver Meadow Coal Company, it is evident that there is more than one flexure in the Beaver Meadow Coal Trough. "In this cutting there is displayed a nearly vertical bed of coal, more than 30 feet in thickness; having, however, a real position or dip of S. 10° E. 85°, and consequently a course or *strike* N. 80° E." To the geological account succeed the descriptions and analyses of various specimens of anthracite.

No. 1. Sp. grav. 1.613. Water, 3.43; gaseous matter volatile at bright red heat, 4.08; carbon not volatile by simple heat, 87.48; earthy matter, 5.01=100.

No. 2. Sp. grav. 1.594. Water, 3.26; other matter volatile at red heat, 1.05; carbon, 91.69; earthy matter, 4.=100. Analysis of the ashes of No. 1 and 2, gave, on an average, silica, 52.375; alumina, 36.745; peroxide of iron, 8.125; lime, 1.550; magnesia, 1.275.

No. 3. Sp. grav. 1.630. Volatile matter, 9.6; carbon not volatilizable by simple heat, 85.337; earthy matter, 5.063=100. The combustible gas given out in the distillation of this coal is of considerable amount, and indicates it as a fuel well adapted for use under steam boilers.

No. 4. Sp. grav. 1.560. Water and combustible gases, 6.89; carbon not volatile by simple heat, 91.64; earthy residuum, 1.47=100.

Prof. J. remarks: "In comparing the results in the above analyses with those of other experiments on anthracite, I find the average amount of carbon much greater than has heretofore been assigned to that species of fuel. Thus, of twelve species of anthracite analyzed by Berthier, the mean per-centage of carbon was 79.15; ashes, 13.25; volatile matter, 7.37."

No. 5. Sp. grav. 1.6127. Combustible carbonic oxide, and a little carburetted hydrogen expelled at red heat, 3.55; carbon not volatilizable by simple heat, 86.06; earthy matter, 3.71=100.

No. 6. Sp. grav. 1.559. Water, .390; gaseous matter, including some azote, volatile at bright red heat, 5.515; carbon, not volatilizable by heat, 91.016; earthy matter and oxides, 3.079=100.

Iron Ores.—The bed of iron ore from which were taken the samples examined by Prof. Johnson, is found on the southern declivity of the bluff, about forty rods northerly from the south fork of Beaver Creek. The thickness of the bed of ore and shale is seven feet, and it lies seventeen feet beneath the surface of the ground at the point where it is opened. The *first* variety analyzed gave by the usual assay in the dry way, the following results:

Water, expelled at 250°, ...	0.4
Carbonic acid, ...	26.6
Cast iron, ...	33.8
Earthy matter, ...	26.64
Oxygen, ...	12.55
	99.99

The ore has a light bluish ash color, is moderately tough before calcination, and has a spec. grav. of 3.247. The pig metal given in the assay is soft, tough, and of a dark gray color. The cinder is a transparent, nearly colorless, glass, very fusible, and contains few adhering particles of metal. The use of pure carbonate of lime as a flux in the proportion of one part of this metal to six parts of raw mine, will produce a complete reduction of the ore and fusion of the earthy ingredients. Assayed in the humid way, this ore yields the following results:

Water, ...	0.40
Carbonate of iron, ...	63.20
" of lime, ...	2.50
" of magnesia, ...	2.27
Oxide of manganese (?)	2.00
Silica, ...	17.50
Alumina, ...	10.55
	98.42

The above quantity of carbonate corresponds to 39.1 per cent. of protoxide or 30.45 per cent. of pure metallic iron, which is 3.35 per cent. below the above yield in *pig metal*, or it is 9.9 per cent. of the pig metal itself, to be regarded as pure iron matter; which is probably very near the true average amount according to the latest and best analyses. The yield in *iron* is equal to the average of Scotch ores in the neighborhood of Glasgow.

The *second* variety of the ore examined, was a sample from the same locality, but from a different part of the bed from that in which the preceding was found. Sp. grav. 2.896. Assayed in the dry way it gave—

Water,	13.12
Pig metal,	44.96
Earthy matter,	24.804
Oxygen,	17.11

The ore seemed to have suffered a change by atmospheric influences, from the condition of a carbonate of the protoxide of iron, to that of a hydrate of the peroxide; in which process some of the earthy ingredients may have washed away. Analyzed in the *humid* way, it gave—

Water,	13.12
Peroxide of iron, with a trace of manganese,	63.65
Silica,	13.45
Alumina,	8.77
Magnesia,	1.01
	100.00

The quantity of peroxide of iron corresponds to 44.55 per cent. of iron, or .41 per cent. less than that of the metal actually obtained. Hence it appears that the quantity of iron remaining in the cinder, is very nearly equal to that of the carbon, &c., in the pig metal.

Near the second bed of coal opened on the slope of the hill north of the northern branch of Beaver Creek, Prof. J. found some ore thrown out in excavating a coal shaft. It is of a brown, or yellowish brown color, compact, with small shining particles. Sp. grav. 3.555.

At a temp. of 330° it loses in moisture,	0.550
By strong calcination, it loses of water,	10.048
It contains of peroxide of iron,	71.120
" earthy impurities,	13.382
	100.

The quantity of pig metal obtained in Prof. Johnson's analysis was 49.77 per cent.; its color dark gray; structure crystalline, granular.

It was soft, tough, and well adapted for foundry purposes. The cinder was a perfect glass, translucent on the edges, of a smoky color, readily fusible before the blow-pipe, and consequently it presents no obstacle to the free running of iron in a furnace. This ore being in the immediate vicinity of the richest of the coals above described, will be a highly valuable resource, if it shall be found in beds of such thickness, and with such accompaniments as to render its attainment not too expensive.

12. *Parasite of the eggs of the Elm-tree Moth.*—On the 15th inst. I noticed several minute insects busily engaged in thrusting their eggs into the eggs of the *Elm-tree Canker-worm Moth*,—(supposed to be the *Geometra vernata* of Peck,) which had been laid a short time previous. On applying a microscope, it was immediately apparent that this parasitic insect belongs to the genus *Platygaster* of Latreille. Of this genus, Say has described *one* American species, (*Contrib. Macl. Lyceum*, p. 81, *Philad.*, 1829.) and Mr. F. Walker has published descriptions of *ninety nine* foreign species, in the *Entomological Magazine*, *London*, *October*, 1835. Whether the insect in question is new or not, I have been too much occupied to determine. Should it prove to be new, I shall endeavor to give some account of it hereafter. The parasite appears quite abundant, and must be of great service in checking the increase of the canker-worm.

E. C. Herrick.

New Haven, November 30, 1839.

13. *Great Earthquakes in Burmah.*—The following account is from a letter written by Eld. E. Kincaid, Baptist Missionary in Burmah, to Dr. L. C. Paine, Albion, N. Y., and published in the Utica Register of Jan. 17th, 1840.

"On the 23d of March, 1839, between three and four in the morning, Ava was visited with one of the most terrible earthquakes ever known in this part of the world. A loud rumbling noise, like the roar of distant thunder, was heard, and in an instant the earth began to reel from east to west with motions so rapid and violent, that people were thrown out of their beds and obliged to support themselves by laying hold of posts. Boxes and furniture were thrown from side to side, with a violence similar to what takes place on board a ship in a severe storm at sea. The waters of the river rose, and rolled back for some time with great impetuosity, strewing the shores with the wrecks of boats and buildings. The plains between Umerapora and the river were rent into vast yawning caverns, running from north to south, and from ten to twenty feet in width. Vast quantities of water and black sand were thrown upon the surface, emitting at the

same time a strong sulphureous smell. As you will suppose, the cities of Ava, Umerapora, and Sagaing, are vast piles of ruins, burying in their fall great numbers of unfortunate people who were asleep at the awful moment. The destruction of life, however, is not so great as might have been expected from the entire overthrow of three large and populous cities. The reason is, the great mass of the people live in wood and bamboo houses. Had the houses in these cities been built of bricks and stone, as cities are built in America, the entire population must have perished. Every thing built of bricks,—houses, monasteries, temples, pagodas, and the city walls, are all crumbled down. Of all the immense number of pagodas in Ava, Umerapora, and Sagaing, and on the Sagaing hills opposite to Ava, not one is standing. The labor and wealth of ages, the pride and glory of Boodhism, have been laid low in the dust in one awful moment. * * *

"Letters from Ava up to the 11th of April, inform us that the rumbling noise, like distant thunder, had not yet ceased; and shocks, often considerably violent, were felt day and night, with seldom as much as one hour's intermission. The extent of the great shock, or rather the succession of great shocks on the morning of the 23d of March, is not yet fully ascertained. It was felt so severely in Maulmein, that many sprang out of bed, supposing a gang of thieves had broken into the house, yet it was not violent enough to do any damage. As far as is now ascertained, Prome to the south, and Bomee to the north of Ava, were entirely overthrown by the earthquake; so that from Prome to the borders of China, more than six hundred miles north and south, embracing the most populous parts of the empire, not a single pagoda, temple, or brick building is left standing. The earthquake was severe in Arracan, and an old volcano on the island of Bromree was re-opened, and the long-concealed fires, mingled with smoke and ashes, rose to a fearful height. It remains to be ascertained, how far this great earthquake extended into China; but as there are several volcanoes among the mountains between Burmah and China, it is more than probable to me that there are subterranean communications between these volcanoes in the north and the volcanoes to the south, as among the mountains between Arracan and Burmah, and in the island of Bromree, and also on the Andeman islands in the Martiban gulf.

"The two extremes are more than one thousand miles apart, in a direct line north and south. But the fact that the whole intermediate country was shaken at the same moment, and a prodigious subterranean noise was heard, resembling the rolling of thunder, is, I think, satisfactory evidence that there are subterranean communications between these widely separated volcanoes. How else can we account

for so terrible an earthquake over so vast an extent of country? The coincidence of volcanic eruptions and earthquakes is not remarkable, but that several hundred miles of territory, with all its mountains and rivers should be thrust up and thrown into undulating motions at the same moment of time, accompanied by sounds from the depths of the earth, like the rolling of thunder, are phenomena which cannot be accounted for on any other supposition than that of vast subterranean lines of communication between volcanic mountains."

14. *Progress of the U. S. Exploring Expedition.*—The following letter from the Commander of the Expedition was received by the Navy Department about the close of January, 1840.

U. S. Ship Vincennes, Matavai Bay, Island of Tahiti, Sept. 15, 1839.

Sir—I have the honor to report my arrival at this anchorage, after a passage of sixty days from Callao; having been employed in examining and surveying many of the islands to the northward and eastward; and take leave to submit the following report of the operations of the exploring squadron, under my command, since my report dated at Callao on the first of July last.

We sailed from Callao on the 13th of July, after completing our supplies of stores and outfits, having been much expedited by the facilities and kind attentions of Capt. McKeever, in command of the United States ship Falmouth.

We steered a westerly course through the trade wind, with fine weather. On our track we passed over the location assigned to an island, as laid down in Arrowsmith's chart, but saw nothing of it, or any appearance of land in the vicinity.

On our route, daily observations were made of the deep sea temperature and dip. We made the island Clermont de Tonnin on the 13th of August, of which we completed a survey, and ascertained the longitude of its southeast point to be 136° 21′ 12″ W. and latitude 18° 32′ 49″ S.

From thence we proceeded to Serle Island, the distance from Clermont de Tonnin being twenty seven miles. Here, again, we made a careful survey of the island, finding its southeast point in longitude 137° 4′ 10″ W. and latitude 18° 21′ 10″ S.

We saw nothing of Minerva Island.

We then proceeded to the northward toward the Disappointment group of Byron, and in our way fell in with Hondon Island, (which was uninhabited,) and found its southeast point in longitude 138° 47′ 36″ W., latitude 14° 55′ 40″ S.

From thence to Wyhite, one of the Disappointment group, the northwest point of which we found in 141° 17′ 24″ W. longitude, and

14° 10′ 30″ S. latitude. We surveyed the island, and had communication with the natives. From thence we steered to the second island, Otooho, and found the longitude of its centre to be 141° 29′ 50″ W., and latitude 14° 3′ 20″ S. After which we again steered to the southward for Ravaka, lying to at night, owing to the dangerous navigation; and on the 30th of August we made an island to the northward of Rarika, not laid down on any chart, which I named King's Island, from the name of one of the crew of this ship, who first discovered it from aloft. We made a survey of it, and found the longitude of its centre to be 144° 37′ 45″ W., and latitude 15° 44′ 10″ S. We landed, but could find no inhabitants, although there were appearances of the pearl fishery having been carried on by the natives.

From thence we visited Rarika, and made a survey of it; the longitude of the entrance to its lagoon is 144° 57′ 52″ W., latitude 16° 5′ 30″ S. We landed, and found the natives very friendly. We took on board one Englishman from this island, who had been left by a vessel engaged in the pearl fishery some time previous.

To the westward, and in sight of Rarika, we discovered another large island, which is not laid down on any chart, which I named Vincennes Island, after this ship; its southwest point is in longitude 145° 12′ W., and latitude 16° 39″ S.; northwest point in longitude 145° 18′ W., latitude 15° 52′ 40″ S.

From thence we made Carls-Hoff, 28 miles to the westward, and in longitude 145° 28′ 36′ W., latitude 16° 36′ S., which, finding erroneously laid down, we surveyed.

From thence we made King George's group, and searched for the two islands westward of them, which have hitherto been considered doubtful, and were supposed to be the Waterland of Le Maire. The northern island, Wilson or Waterland, is in longitude 146° 5′ 57″ W., latitude 14° 26′ S. These we surveyed, and having ascertained the existence of two islands, I named the second one Peacock Island, as that ship first made the signal of having discovered it; its longitude is 146° 25′ 37″, latitude 14° 34′. Here I had an opportunity of observing the eclipse of the sun, (Sept. 7.)

The squadron then separated; the Peacock passed to the Rurick chain of islands and along the south side of Prince of Wales island, the Vincennes taking the north side, the Porpoise and Flying Fish having been ordered to make investigations of islands in that vicinity.

These islands have been carefully examined on all sides, which has resulted in detecting many errors of the charts and of former determinations.

From thence we proceeded to Matea island, which we surveyed, and from thence direct to this anchorage.

The explorations and surveys were made in the boats and vessels, frequently running with the vessels within a quarter or half a mile of the shore and coral reefs; and I am happy to inform you that notwithstanding the dangerous navigation among these islands, we have escaped without accident, and I flatter myself that I have carried into effect most fully all that part of your instructions referred to in the notes of Admiral Krusenstiern, which were attached to and formed a part of t. em.

No opportunity has been omitted to land upon the islands and establish a friendly intercourse with the natives, and to make all possible observations and collections in the different departments, all of which will be disposed of agreeably to your instructions.

On my arrival here, I was gratified to find by the observation had at point Veners, my chronometers in error only 1′ and 3″ with the longitude of that point.

I shall remain here only a few days to complete our observations and procure a supply of wood, water, fresh provisions, and vegetables, for the crew, and proceed to carry out your farther instructions with all dispatch. I have the honor to be, Sir, most respectfully,

Your obedient servant,

CHARLES WILKES, *Commanding Exploring Expedition.*

To the Hon. J. K. PAULDING, *Secretary of the Navy.*

15. *The Twilight Bow.*

To the Editors—I have for several years been in the habit of observing a daily meteorological phenomenon which occurs twice in the 24 hours, and which, so far as I have been able to ascertain, has never been noticed in any scientific work, and yet seems worthy of the attention of philosophers. I mean the appearance, morning and evening, of a prismatic bow. Having shown the bow to several friends, they were equally struck with the fact that so obvious, and at the same time so beautiful a phenomenon, should not have attracted attention. It may still have been noticed in some scientific journals, though it has escaped my observation.

The bow in the morning begins to be defined in the west about half an hour before sunrise. The height of the arch is about 15° above the horizon, and spans nearly, perhaps quite, 180°. Its first aspect is that of a blue belt, the red next appears like a faint blush above the blue, producing the purple as it mingles with the blue. Then appears the yellow above the red, producing the orange as it mingles with the red. As the sun advances towards his rising, the bow descends to coincide with the horizon, and at an angle of 8° above the horizon, or about 15 minutes before sunrise, the colors are most dis-

tinct and concentrated. At sunrise, the bow coincides with the horizon.

In the appearance of the evening bow, the whole process of appearance and disappearance is in a reverse order: the bow is in the east; it rises at sunset, and disappears in about half an hour.

The bow is best seen in the clearest atmosphere, and then an hour before sunrise, a second series of colors forms another bow within the other, and the same height above the horizon, very faint, it is true, and diffuse, but still very perceptible; so that the series of colors, naming them as they proceed from the centre, and always naming the yellow first, would be yellow, blue, red, yellow, blue, red. I have long observed in examining the various series of prismatic rings that occur in nature, that the order of colors is not the same in the various series. Now in a series of three, we can have but two orders; either there will be 1, 2, 3; 1, 2, 3; or 1, 3, 2; 1, 3, 2. In the prismatic spectrum there are but three primitive colors. Every series of concentric prismatic rings will therefore be one of two orders. The choice of a color to commence with in reading the orders of colors in any series, is indeed arbitrary, the result will always be the same, but as it is necessary to fix upon one, let us fix upon the yellow, and always read from the centre outwards; this method will fix the order of any series, and the two orders may then very properly be termed the *blue* order or the *red* order, according as the *blue* or the *red* follows the yellow in reading the series. To illustrate these remarks I would state, that the rings produced by thin plates are of the *red order;* the halo round the moon is of the *blue order;* the series round a candle, seen through gauze, is of the *red order;* the series on metallic plates, produced by throwing the flame of a blow-pipe perpendicularly upon a plate of metal, is of the *blue order;* the rainbow is of the *red order;* and in conformity with this arrangement, the bow which I have been describing, and which may perhaps with propriety be called the *Twilight Bow*, is of the *blue order.*

Perhaps some of your correspondents can explain this meteorological phenomenon. Your obedient servant,

SAMUEL F. B. MORSE.

New York City University, Dec. 1, 1839.

Note.—The *Twilight Bow* has, we believe, been often observed, but we do not know that any description of it is to be found in print. The blue portion of the arch appears to lie within the earth's shadow.—*Eds.*

16. *Lectures on Phrenology, by George Combe, Esq., of Edinburgh, in New Haven.*—A large audience, embracing a fair propor-

tion of cultivated minds, recently listened attentively to Mr. Combe's lectures on phrenology and mental philosophy, delivered in New Haven. His course occupied thirteen evenings, each lecture being two hours long, with an intermission of five minutes.

A thirteenth lecture, on physical education, was added to the usual course of twelve, and paid for extra, at a very reasonable rate, in order to purchase his collection of busts and masks, which object has been effected in consequence of a full attendance for that purpose, and they are to remain in New Haven.

During the eighteen months that have elapsed since the arrival of Mr. Combe in this country, its people have, in many places, enjoyed the opportunity of hearing phrenology explained by one of its most accomplished professors. The sterling good sense and integrity—the extensive and various science—the numerous illustrative anecdotes—the clear method—the unity of design and execution—the simplicity of language and the absence of all pretension, which characterize Mr. Combe's lectures, have secured for him the respect, esteem and kind regard of his hearers.

That all who listened, especially for the first time, to the details of this extraordinary branch of science, should fully adopt, or even entirely comprehend them, is not to be expected. But whatever opinion may be formed respecting the external manifestation of the mental powers and sentiments by the size and figure of the cranium, no one can doubt that all which distinguishes man from the animals, is manifested through his mind—that the propensities and the faculties are real, and therefore an able analysis of them by a master, must ever be an interesting and instructive thing. There is no doubt that the knowledge admits of important practical applications, and that a just comprehension of human physiology and anatomy, would correct many errors in education, and lead the way to reform in many important particulars as regards our habits of life.

We have no time or space in this passing notice, to add any thing more than our good wishes for Mr. Combe, assured that he has made very favorable impression of his powers and character in the country which he is about to leave.

17. *Proceedings of the Boston Society of Natural History, compiled from the Records of the Society, by* Jeffries Wyman, M. D., *Recording Secretary.*

Oct. 2, 1839.—George B. Emerson, Esq., President, in the chair.

The president made a report on a specimen of the *Lycopodon giganteum*, of Batsch. Its greatest circumference was 3 feet 4½ inches;

least do., 2 feet 9½ inches; greatest length, 1 foot 3 inches; weight, 6 pounds. At a distance, it had the appearance of a large bundle made of very dirty silk; near at hand, it resembled dirty white buckskin, or kid. It rested on the ground, its point of attachment being a very short, black stipe, around which the skin had the furrowed appearance of a handkerchief drawn together to tie at the corners. The surface, examined under a microscope, had the appearance of common white leather. The covering, or peridium, is twofold; the external layer is rather thin, and almost imperceptibly scaly; the inner, rather tough and thick. The substance within was of a close, soft, leathery, approaching to a fleshy consistence, having but little firmness. After having been kept a short time it became exceedingly offensive; it however ceased to be so after the third or fourth day.

Berkely says that the *bovista* sometimes attains the size of many feet in circumference, and when wounded, it heals by forming a web in the interstices, somewhat analogous to the veins of the truffle.

Oct. 15, 1839.—C. K. Dillaway, Esq., in the chair.

Dr. D. H. Storer read a communication from Dr. J. P. Kirtland, of Ohio, describing fifteen species of fishes, accompanying which were colored drawings. The species are as follows: *Luxillus elongatus, Semotilus biguttatus, Semotilus cephalus, Amia colva, Luxillus dissimilis, Petromyzon argenteus, Icthelis aurita, Icthelis nitida, Coregonus Artedii, Lota maculosa, Catostomus aureolus, Etheostoma blenioides, E. caprodes, Sciæna oscula, and Cychla fasciata.* Of these species five are new, and ten have not before been figured. Dr. Kirtland hopes to continue these communications till all the fishes of the western waters have been described.

Dr. T. M. Brewer stated that recently he had an opportunity to examine the habits of certain birds, while on an excursion through the States of New Hampshire, Vermont and New York. His attention had been more particularly turned to the habits of the *Hirundo fulva*, (Vieillot,) variously known as the *Republican, Rocky Mountain, Cliff, Eave and Square-tailed Swallow.* He had found their nests in Jaffrey, N. H., to the number of one hundred and twenty, disposed in a single line, and completely occupying the eaves on one side of an old wooden church. A few were engaged in feeding their young as late as Aug. 20. The note, both of the young and the parent, is a sharp and shrill twitter, as loud and piercing as that of the canary bird. They made their first appearance in Jaffrey, also in New Ipswich, during the present season. They have however been observed for several years in Nelson, N. H., from which place probably emanated the colonies of more recent date. This bird was first described by

Vieillot, in 1807, from specimens obtained in St. Domingo. It has, however, been for many years past known as a resident of the Rocky Mountains, from which region it has gradually moved eastward, and has been successively discovered in Kentucky, upon the banks of the Ohio, in New York, Maine, and of late in other New England states, their appearance being followed by the partial exclusion of the barn swallow. The nest, generally found in colonies, but occasionally solitary, is composed of clay, having the form of an inverted retort bulb, the mouth being below and the interior lined with soft substances.

Nov. 20, 1839.—George B. Emerson, Esq., President, in the chair.

Amos Binney, Esq., made a report on the volume entitled, *Reports on the Fishes, Reptiles and Birds of Massachusetts*, giving a detailed account of the history and progress of these Reports, and entering into a critical examination of their contents.

The report on Fishes by Dr. Storer, makes up the greater part of the volume, and constitutes an important contribution to American natural history. Considering the short period of time allowed for its completion, it is exceedingly creditable to the author's science, and to his diligence and perseverance. A new impulse has latterly been given to the study of ichthyology, by the publication of the works of Cuvier and Valenciennes, and of Yarrell. The cultivators of science will hail the present work with pleasure, as coming from a country whose ichthyology was not long since pronounced by Cuvier to be a desideratum in natural history. But its appearance has an importance at this time independent of its own particular merits, since it will serve as an effective check to the propagation of the mistakes and impositions of another work on Massachusetts fishes, which has already been quoted by respectable authors, and which was thus beginning to introduce confusion and error into science.

Of the small number of fishes appertaining to our territory, the whole number described being one hundred and nine, it is truly wonderful that they comprise all those genera and many of the species which contribute so largely to the subsistence of mankind, and which have for ages furnished the materials of an important branch of the commerce of nations. The pages of this work furnish ample proof of their importance to our community, by making known the fact that there are eighteen species which are objects of extended trade, and fifty-nine additional species, which, distributed by the bountiful hand of nature in countless numbers in the sea and fresh waters, and within reach of the poorest citizen, are or may be used as wholesome and nutritious food; while there only thirty-three species, which from their diminutive size, their hideous form, their coarse structure, or from some prejudice

connected with them, are absolutely rejected. It has been said that he should be considered a public benefactor, who makes but a single blade of grass grow where none grew before; the same honor ought truly to be accorded to another, who, though he cannot create, makes known to the community the existence of a new species of edible fishes, or that a species already known, though shunned or rejected from some unfounded prejudice, may be used with safety and advantage. This has been done to a considerable extent in this book, and no doubt with useful effect.

The new species described are ten; one, constituting a new genus, to which the author has given the name of *Cryptacanthodes maculatus*. It is of the family of "mailed cheeks," and particularly distinguished from any other genus of this family, by the existence of concealed spines on the operculum, preoperculum and scapular bones. It seems to be established on correct principles, and will undoubtedly be adopted by ichthyologists. The other new species are

Pholis sub-bifurcatus,
Leuciscus argenteus,
" pulchellus,
Morrhua Americana,
Platessa ferruginea,
Echeneis quatuordecem-laminatus,
Syngnathus fuscus,
" Peckianus,
Monocanthus Massachusettensis.

One of these is the common cod, of Massachusetts Bay, which Dr. Storer considers not to be sufficiently identified with the *Morrhua vulgaris*, of Europe, and therefore describes it as a new species, under the name of *M. Americana*. If this is a new species, it is a most extraordinary instance of a most abundant animal having passed through the hands of various observers, for a great length of time, without detection, including within their numbers so celebrated a naturalist as Pennant. But it may be considered as very doubtful whether this be any thing more than a variety. The same fish appears to have been noticed by Dr. Mitchill, in his paper on the fishes of New York, as the *M. callarias*, (Lin.) The remarks of Dr. Storer prove very clearly that it is not the European *callarias*; but it is doubtful whether Richardson's remark on Mitchill's, "that it is probably a distinct species," meant any thing more than that it was distinct from the *callarias* of which he was then speaking. Yarrell, who was evidently acquainted with Mitchill's description, considered it to be the common cod, as must be inferred from his quoting his words under his own description of *Morrhua vulgaris*. He also states most ex-

pressly, that the eastern coast of America, from the latitude of 66° north, to that of 40°, is abundantly frequented by them. Le Sueur, too, an excellent ichthyologist, and well acquainted with the markets of New York and Boston, where this fish may always be seen, did not consider it a novelty, although on the look-out for new species. The difference in the descriptions of the two species is not greater than that between other species inhabiting the shores of both continents. The number of fin-rays, particularly, seem to vary greatly from English species; the number stated by Yarrell and Dr. Storer, never corresponding, except in the ventral fin, which, in the family of Gadidæ, the only one in which comparison has been made, correspond in every instance. The question of identity now raised, will no doubt soon be determined, it being very easy to procure, through the fishermen, specimens of the true bank cod for examination.

There are in the work some few errors of fact, and inaccuracies of language, which, though of little importance in themselves, deserve notice, that the author's attention may be called to them, in anticipation of a reprint of his work, which without doubt will be called for before any considerable time shall elapse.

These remarks on the report on fishes, will be concluded with the expression of a sincere hope, in which I doubt not all will participate, that Dr. Storer will continue to give his attention to this subject, and will from time to time bring before the society such new information as he may acquire.

Having given so much time to the first report, there remains but little for the reptiles. The number of species of this class described is only forty. Of the order Chelonians there are eight, divided among the genera *Emys*, *Sternotherus*, *Emysaurus*, *Cistuda*, and *Sphargis*. The numerous order of Saurians is represented by a single lizard. Of the Ophidians there are twelve, one of which, *Coluber occipito-maculatus*, is a newly described species. The Batrachians number seventeen, viz. of the genus *Rana* four, *Hylodes* one, *Hyla* two, *Bufo* one, *Salamandra* nine. The descriptions are shorter and less elaborate than those of the fishes, and do not seem to have been produced with the same satisfaction to the author, but are entirely creditable to him.

The number of species belonging to the class of reptiles in this state, is without doubt destined to be very much enlarged. The Emydes or fresh-water tortoises, and the Salamanders, two genera which are distributed in extraordinary numbers in North America, have not yet contributed their full proportion to the list. In conclusion, the Society may be congratulated on the appearance of these reports. They are the legitimate fruits of the exertions of this institution in

disseminating new tastes and new sources of pleasure and usefulness in the community. Taking into view their public character, they are the best proofs of the success of our efforts, and should incite us to new endeavors in the same cause.

Dr. D. H. Storer exhibited the tails of two species of Ray, probably of the genus *Cephaloptera*, both of which were provided with two strong serrated spines near their anal extremities. One of the specimens was smooth and the other covered with short and conical spines. He also stated that a species of *Solea*, had been found in the waters of Massachusetts during the last six months.

Dec. 4, 1839.—George B. Emerson, Esq., President, in the chair.

Prof. C. B. Adams read descriptions of two new species of shells, obtained by dredging, from the bottom of the harbor at New Bedford, viz. *Pleurotoma plicata* and *Tornatella puncto-striata*. He also stated that the *Pholas costatus* hitherto unknown in our waters, had also been found in the same locality.

Prof. A. also read additional descriptions to the following species of Say, viz. *Natica heros ; Turbo aculeus ; Solicurtus costatus*, and *Solen costatus*.

Dr. A. A. Gould made a report on the shells from California committed to him at a previous meeting. He found them to consist of *Murex tricolor* and *bicolor ; Cardium Californianum*, *Trochus vittatus*, *Bulimus undatus*, and several species of *Purpura*.

Dec. 18, 1839.—Amos Binney, Esq., Vice President, in the chair.

Prof. C. B. Adams read descriptions of two new species of shells, viz. *Jaminia producta* and *Ancylus fuscus*, from Andover Mass. He also exhibited specimens of *Valvata tricarinata*, in which the carinæ were very indistinct.

Dr. D. H. Storer made a communication to the Society, stating that all the specimens in the ichthyological cabinet had been arranged in their appropriate genera, and, as far as practicable, in their geographical localities. The whole number of genera now in the cabinet is one hundred and fifty eight, containing three hundred and forty four species ; of which one hundred and eighteen genera, and one hundred and ninety four species have been added during the last two years.

18. *Proceedings of the American Philosophical Society, Philadelphia. September* 20, 1839.—Professor Bache, on behalf of the Committee appointed on the paper of Professor Elias Loomis, of Western Reserve College, Ohio, entitled " Observations to determine the

Magnetic Dip at various places in Ohio and Michigan," reported in favor of publication, and the Report was adopted.

The observations recorded in this paper were made with a dipping needle by Gambey. The results are contained in the following table.

Place.	Latitude.	Longitude.	Date.	Magnetic dip.
Hudson, Ohio, .	41° 15′ N.	81° 24′ W.	September, 1838.	72° 48.2′
Hudson, Ohio, .	41 15	81 24	April, May, 1839.	72 46.8
Cleveland, Ohio,	43 30	81 51	May, "	73 26.0
Detroit, Michigan,	42 19	83 03	" "	73 42.6
Ann Arbor, do.	42 18	83 45	" "	73 13.9
Ypsilanti, do.	42 14	83 38	" "	73 18.0
Monroe, do.	41 55	83 28	" "	73 32.3
Toledo, Ohio,	41 41	83 33	" "	73 06.1
Maumee city, Ohio,	41 34	83 38	" "	72 49.1
Sandusky, Ohio,	41 29	82 48	" "	72 57.8

Professor Loomis infers from a comparison of these observations with others made in the eastern part of the United States, that the lines of equal dip intersect the parallels of latitude, their direction being from about N. 82° W. to S. 82° E.

Dr. Chapman, from the Committee appointed to apply to Mrs. Madison, for certain meteorological observations made by the late President Madison, reported that a number of documents had been received, and presented them to the Society. The secretaries were directed to return thanks to Mrs. Madison for this donation.

A necrological notice of the late Bishop White, prepared in pursuance of the request of the Society, by Bishop De Lancey, was read.

Dr. Chapman announced the death of Matthew Carey, of Philadelphia, a member of the Society, and Mr. Lea was requested to prepare an obituary notice of the deceased.

Dr. Bache announced the decease of Dr. Robert Perceval, of Dublin, a member of the Society.

The Librarian of the Society was authorized to furnish to the family of the late Dr. Bowditch, to be placed in the library of the deceased, any volumes of the Transactions which may be deficient in the set belonging to Dr. Bowditch, and the future volumes, so long as the library shall be kept open for public use.

Dr. Hays presented a table, compiled by him,of the peculiarities in various cases of individuals not able properly to distinguish colors. Mr. Kane added the comparisons which he had made, in the case of a friend, with the specimens named by Dr. Dalton, of Manchester, in the possession of Professor Bache.

Professor Bache made a verbal communication of the measures taken by the British government, on the recommendation of the British

Association, and under the advice of the Royal Society, for obtaining a series of magnetic observations in different quarters of the globe, in conjunction with a naval expedition in the southern hemisphere, under the command of Capt. James Clark Ross, and read extracts from letters of Professor Lloyd and Major Sabine, relating to the preparation for the undertaking.

Professor Bache further stated, that on submitting the circular addressed to him by the Foreign Secretary of the Royal Society, with extracts from the letters before referred to, and other information as to the nature and importance of the results to be obtained by this combined system of magnetic observations, to the Building Committee of the Girard College, through their Architect, they had, with creditable liberality, given orders for the erection of an observatory suited to the observations contemplated, and to the instruments already in the possession of the Trustees of the College.

Professor Bache submitted the plans of the observatory drawn by Thos. U. Walter, Esq. Architect.

Mr. Justice made some remarks in continuation of those offered at the last meeting of the Society, in support of his opinion of a gyratory motion in the tornado, of the 31st July, 1839, the destructive effects of which were felt about seventeen miles north of Philadelphia.

October 4, 1839.—The Committee, consisting of Dr. Dunglison, Mr. Kane, and Mr. Lea, to whom were referred a letter of the Rev. Charles Gutzlaff to John Vaughan, Esq. dated Macao, January 2, 1839, and the letter of Peter S. Du Ponceau, Esq. to the same gentleman, dated Philadelphia, September 20, 1839, made their report, which was read and accepted.

The communication of Mr. Gutzlaff was suggested by the dissertation of Mr. Du Ponceau, "On the nature and character of the Chinese system of writing." As the results of his reflection and observation, Mr. Gutzlaff affirms, that China was the great centre of civilization, whence it diverged to all the countries of Eastern and Southern Asia; the colonists from China driving the autochthonous tribes into the mountains, and incorporating the country itself, including Tunkin and Annam, with the central kingdom. A constant influx of Chinese also took place into Korea, but the emigration to Japan and the Loo Choo Islands was less extensive.

Chinese words, and the Chinese art of writing, were thus introduced into these countries; Chinese books became their literature; and, like the Latin in the middle ages, the Chinese was the language of the learned. Yet all the nations that have adopted the Chinese mode of writing, speak a language more or less distinct from the written idiom. The different nations, too, who employ the Chinese characters, call

them differently, using their own language to designate them, and they, as well as the Chinese themselves, have to learn the meaning of the characters from teachers, who explain them in the dialect spoken amongst the people. The dialects spoken by the different nations, who use the Chinese character, are very distinct from the language of China proper. The Koreans and Japanese, whilst they transact all important business in the Chinese character, have a syllabary with which they write their own language. The Cochin Chinese occasionally use the Chinese in a contracted form, without any reference to its meaning, to express sounds, but they have no syllabary.

It is not strictly true that sound is not inherent in the Chinese character. A majority of the signs are not pronounced by the Chinese at random, nor do the nations abandon all analogy in reading them, although they vary much. Mr. Gutzlaff has been struck with the ease with which communication may be held with the Cochin Chinese, Japanese and Koreans, by means of the Chinese character, even without comprehending a word of their idiom. This, he says, does not refer to the learned classes only, but to the very fishermen and peasants, with some exceptions only. In the Loo Choo Islands, men of distinction talk Chinese with great fluency, but the mass of the people speak a dialect of the Japanese, and employ the Chinese character as well as the Japanese syllabary. Mr. Gutzlaff considers it certain, that the nations who have adopted the Chinese character, attach the same meaning to it as the natives from whom it was originally derived, and that its construction is likewise retained with scarcely any alterations.

The communication of Mr. Du Ponceau is a rejoinder to that of Mr. Gutzlaff. Mr. Du Ponceau repeatedly combats the notion entertained by some, that the superiority of the Chinese alphabet is such that it forms a kind of pasigraphic system, which may be adapted to every language. He admits, to a certain extent, what he was disposed at one time to doubt, that the Chinese characters do actually serve as a means of communication between different nations, who can neither speak nor understand each other's oral language, and he investigates at some length, the causes by which the effect is induced; but he expresses himself at a loss to understand how the fishermen and peasants of Japan, Korea and Cochin China, "with only some exceptions," can be readily communicated with by means of Chinese characters, even by a person who does not understand a single word of their spoken language. The remark of Mr. Gutzlaff, he conceives, cannot be meant to imply that all, or nearly all the fishermen and peasants of the countries referred to, can read and write the Chinese; for, on the authority of Mr. Medhurst, there are villages, even on the coast of China, where few, if any, of the inhabitants can either read or write. If,

however, the assertion of Mr. Gutzlaff be assumed to be rigorously accurate, it will have to be explained by the circumstance, that as the Chinese is esteemed a universal medium of communication between the people referred to, it is more extensively taught amongst them than even amongst the Chinese themselves.

Mr. Du Ponceau enters, at some length, into the nature of the four languages, or classes of languages which are embraced in the communication of Mr. Gutzlaff. 1. Of the various dialects of the Chinese. 2. Of the Annamitic languages. 3. Of the languages of Japan and the Loo Choo Islands; and 4. Of the Korean; the two first of which are monosyllabic, the two last polysyllabic; and from all the facts and reflections, he concludes, that the circumstance of the Chinese characters being understood so extensively amongst these people, is not owing to any thing inherent in the Chinese characters, in their shape or greater perspicuity, but to their connexion with the languages from which they were formed, and to the mode in which they have been adapted to them. The vernacular languages of Japan, the Loo Choo Islands, and Korea, are so different from the Chinese, that it was found impossible to apply to them the Chinese system of writing; consequently, when the people of these countries read the Chinese characters, they do not read them in their native language, but in the Chinese, which they have acquired, but pronounce differently from the Chinese themselves. This is not the case with the people of Tunkin and Cochin China—the Annamites; their language or languages being formed on the model of that of China, with some variations, which they learn, in their schools, to correct, and to employ the proper characters as a superior orthography, by which they are enabled to read the Chinese as well as their own language.

The Committee recommended that the interesting communications of Mr. Gutzlaff and Mr. Du Ponceau, tending as they do, to elucidate a contested topic of Oriental philology, be published in the transactions of the Society.

Dr. Hare made a verbal communication on the subject of tornadoes, and on his electrical theory of their formation, supporting his views by reading an extract from a Memoir by M. Peltier, describing a destructive tornado which occurred near Paris, in June last.

Dr. Hare stated that agreeably to a publication in the Journal des Débats for the 19th of July, some losers by this tornado having effected insurance against damage from thunder gusts, applied to the insurers for indemnity, which was refused, upon the plea that a tornado was not a thunder gust (orage). The question having been submitted to Arago, it was by him referred to Peltier.

Peltier, after due investigation, came to the conclusion that a tornado is a modification of the thunder gust, in which, in lieu of passing in the form of lightning, electricity passes through a cloud, acting as a conductor between the terrestrial surface and the sky. It will be perceived that this view of the subject differs but little from that which, in a memoir in the transactions of the Society, had been presented by Dr. Hare, in the following language:—"A tornado is the effect of an electrified blast of air, superseding the more usual means of discharge between the earth and clouds, in the sparks and flashes which we call lightning. I conceive that the effect of such a current would be to counteract, within its sphere, the pressure of the atmosphere and thus to enable this fluid, in obedience to its elasticity, to rush into the rarer medium above."

Dr. Hare went on to say, that the only difference arises from the omission of the Parisian philosopher to call in the elasticity of the air in aid of the electrical forces, and his assigning to a cloud the agency which Dr. Hare had attributed to a vertical blast of electrified air, mingled with every species of movable matter coming within the grasp of the meteor; and that it would seem, from a subsequent communication made by Peltier to the Institute, that he had so entirely misapprehended Dr. Hare's theory, as to ascribe to it deficiencies for which it was not amenable, but which had existed in his own explanation, as stated in his report.*

The fault of Dr. Hare's explanation was, according to him, "*en ne tenant pas compte des forces nouvelles que la première*, (that is to say, the electric attraction,) *acquiert par le mouvement gyratoire qui accompagne souvent la coulonne de nuages et d'eau qu'on appelle trombe.*"

As the most appropriate refutation of this misstatement, Dr. Hare stated that he would quote a paragraph from his Memoir.

"*When once a vertical current is established, and a vortex produced, I conceive that it may continue after the exciting cause may have ceased.*

"*The effect of a vortex in protecting a space about which it is formed, from the pressure of the fluid in which it has been induced, must be familiar to every observer. In fact, Franklin ascribed the water spout to a whirlwind.*

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* Tout confirme donc que la trombe n'est qu'un conducteur nuageux; qu'elle sort de passage aux decharges continuelle de nuages superieure que la difference entre un orage ordinaire et l'orage accompagné du trombe, est dans ce conducteur servant à établir le combat entre l'extremite de la trombe, et la portion du sol situé au dessous. (See Peltier's report upon the tornado of Chatenay, *Journal des Debats du* 17 *Juillet*, 1839.)

"*His hypothesis was I conceive, unsatisfactory, because it did not assign any cause for the concentration of the wind, or for the hiatus presumed to be the cause. This deficiency is supplied, if my suggestions be correct.*"

On reading this passage, after previously hearing or reading the allegation above quoted, that Dr. Hare's hypothesis was defective in not appealing to a gyratory movement, it was presumed that it would be perfectly evident to every one, that, from ignorance of English, or inattention, Mr. Peltier's statement was the reverse of the reality.

In proof of a gyratory force having been exercised during the New Brunswick tornado, Dr. Hare referred to his having, in his Memoir, cited the case of a chimney, of which the upper portion had been so twisted upon the lower portion, as to have its corners projecting over the sides of the latter; but he had now taken a different view of that fact, which had since struck him as being of much higher importance than he had formerly considered it.

During an examination of the track of the tornado which lately ravaged the suburbs of New Haven, Conn., Dr. Hare had been led to infer that the electrical discharge is concentrated upon particular bodies, according to their character, or the conducting nature of the soil; so that the vertical force arising from electrical reaction, and the elasticity of the air, acts upon them with peculiar force. Hence, while some trees were borne aloft, others, which were situated very near them on either side, remained rooted in the soil. In two instances at New Haven, wagons were especially the victims of the electro-aërial conflict. In the case of one of these, the axletree was broken, and while one wheel was carried into an adjoining field, the other was driven with so much force against the weather-boarding of a barn, as to leave both a mark of the projecting hub, and of the greater portion of the periphery. The plates of the elliptical springs were separated from each other. During the tornado at New Brunswick, the injury done to some wagons in the shop of a coach-maker, appeared at the time inexplicable. It was now inferred, that the four iron wheel-tires, caused by their immense conducting power, a confluence of the electric fluid, producing a transient explosive rarefaction, and a subsequent afflux of air with a local gyration of extreme violence.

It may be reasonably surmised, that the excessive injury done to trees results, not from the general whirl, but from a local gyration to which they are subjected, in consequence of the multiplicity of points which their twigs and leaves furnish for the emission of the electrical fluid. The fact that the leaves of trees thus injured, appear afterwards as if they had been partially scorched, seems to countenance this idea. The twisting of the chimney at New Brunswick, as above

mentioned, seems difficult to explain, agreeably to the idea of a general whirl, throughout the whole area of the tornado track. The chances are infinitely against any chimney having its axis to coincide with that of a great whirlwind, forming a tornado; and it must be evident, that in any other position, it could only be subjected to the rotary force on one side at a time. But if this were adequate to twist the upper upon the residual portion, the former would necessarily be overthrown. Evidently, it could not be left, as was the chimney which called forth these remarks.

During the tornado at New Haven, chimneys seemed to be especially affected. One, after being lifted, was allowed to fall upon a portion of the roof of the house to which it belonged, at a distance from its previous situation too great to have been reached, had it been merely overthrown. In the case of a church which was demolished, a portion of the chimney was carried to a distance greater than it could have reached without being lifted by a vertical force.

It appeared quite consistent that chimneys should be particularly assailed, since that rarefaction, which, by operating upon the roofs of houses, carries them away, must previously cause a great rush of air through the chimney flues. But this concentration of the air must tend to facilitate the "convective"* discharge in that direction; since an electrical discharge by a blast of air, is always promoted by any mechanical peculiarities favoring an aërial current or jet.

That during a recent tornado in France, articles were carried from the inside of a locked chamber to a distance without, when no opening existed besides that afforded by a chimney, seemed to justify the suggestion that there must be a great rush of air through such openings.†

Dr. Hare also made some remarks on the aurora which occurred on the 3rd of September, 1839, in which he suggested that the electric fluid, producing the phenomena then observed, might have been derived from remote parts of space.

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* A "convective" discharge, or a discharge by "convection," in the very appropriate language of the celebrated Faraday, is a process by which electricity is conveyed by the transfer of electrified bodies from one excited surface to another in an opposite state. This is conceived to be a good definition of the discharge which produces a tornado.

† Dr. Hare did not conceive it proper to trespass upon the time of the Society, to make any allusion to that part of his memoir, in which the three enormous concentric spaces occupied by the earth, the denser non-conducting atmosphere, and the rare conducting medium beyond the denser atmosphere, are represented as competent to perform a most important part in the production of electrical storms; nor did he feel at liberty to make any remarks in support of an opinion which he had recently formed, that a hurricane is a gigantic tornado. Neither had he time to cite the evidence furnished by Reid's work upon storms, in favor of a local force or gyration, like that of which he had seen proofs, arising from the New Haven tornado.

Oct. 18.—The following extract from a letter, addressed by Prof. Henry, of Princeton, to Prof. Bache, was read, announcing the discovery of two distinct kinds of dynamic induction, by a galvanic current.

"Since the publication of my last paper, I have received through the kindness of Dr. Faraday, a copy of his fourteenth series of experimental researches; and in this I was surprised to find a statement directly in opposition to one of the principal results given in my paper. It is stated in substance, in the 59th paragraph of my last communication to the American Philosophical Society, that when a plate of metal is interposed between a galvanic current and a conductor, the secondary shock is neutralized. Dr. Faraday finds, on the contrary, under apparently the same circumstances, that no effect is produced by the interposition of the metal. As the fact mentioned forms a very important part of my paper, and is connected with nearly all the phenomena described subsequently to it, I was anxious to investigate the cause of the discrepancy between the results obtained by Dr. Faraday and those found by myself. My experiments were on such a scale, and the results so decided, that there could be no room for doubt as to their character; a secondary current of such intensity as to paralyze the arms having been so neutralized, by the interposition of a plate and riband of metal, as not to be perceptible through the tongue. I was led by a little reflection to conclude that there might exist a case of induction similar to that of magnetism, in which no neutralization would take place; and I thought it possible that Dr. Faraday's results might have been derived from this. I have now, however, found a solution to the difficulty in the remarkable fact, that an electrical current from a galvanic battery exerts *two* distinct kinds of dynamic induction: one of these produces, by means of a helix of long wire, intense secondary shocks at the moment of breaking the contact, and feeble shocks at the moment of making the contact. This kind of induction is capable, also, of being neutralized by the interposition of a plate of metal between the two conductors. The other kind of induction is produced at the same time from the same arrangement, and does not give shocks, but affects the needle of the galvanometer; it is of equal energy at the moment of making contact, and of breaking contact, and is not affected by the introduction of a plate of copper or zinc between the conductors.* The phenomena produced by the first kind of induction form the subject of my last paper, as well as that of the one before; while it would appear from the arrangement of Dr. Faraday's experiments, that the results detailed in his first series,

* Since writing the account of the two kinds of induction, I have found that the second kind, although not screened by a plate of copper or zinc, is affected by the introduction of a plate of iron. In the cases of the first kind of induction, iron acts as any other metal.

and those in the fourteenth, were principally produced by the second kind of induction. Although I may be too sanguine in reference to the results of this discovery, yet I cannot refrain from adding that it appears to lead to a separation of the electrical induction of a galvanic current from the magnetical, and that it is a step of some importance towards a more precise knowledge of the phenomena of magneto-electricity."

19. *Ehrenberg on the Infusoria.*—The following interesting conclusions are stated in a short review, given in Charlesworth's Mag. of Nat. Hist. London, Oct. 1839, of Ehrenberg's recent work, entitled *Die Infusions thierchen*, etc. (Leipzig. folio. 64 plates.) In the *Infusoria* themselves, Prof. Ehrenberg has either confirmed or first established a considerable number of very curious qualities and relations, which are highly interesting in a physiological and other points of view, the most important of which we briefly enumerate.

1. Most (probably all) microscopic *animalcula* are highly organized animals. 2. They form, according to their structure, two well-defined classes. 3. Their geographical distribution in four of the parts of the world follows the same laws as that of other animals. 4. They cause extensive volumes of water to be colored in different ways, and occasion a peculiar phosphorescence of the sea by the light they develop. 5. They form a peculiar sort of living earth; and as 41,000 millions of them are often within the volume of *one cubic inch*, the absolute number of these *animalcula* is certainly greater than that of all other living creatures taken together; the aggregate volume is even likely to be in favor of the *animalcula*. 6. They possess the greatest power of generation known within the range of organic nature; one individual being able to procreate many millions within a few hours' time. 7. The *animalcula* form indestructible earths, stones, and rocks by means of their siliceous *testæ:* with an admixture of lime or soda they may serve to prepare glass; they may be used for making floating bricks, which were previously known to the ancients; they serve as flints, as tripoli, as ochre, for manuring land, and for eating, in the shape of mountain meal, which fills the stomach with a harmless stay. They are sometimes injurious by killing fish in ponds, in making clear water turbid, and in creating miasma; but that they give rise to the plague, *cholera morbus*, and other pestilential diseases, has never been shown in a credible manner. 8. As far as observation goes, the *animalcula* never sleep. 9. They exist as *Entozoa* in men and animals, the *Spermatozoa* not being taken into consideration here. 10. They themselves are infested with lice as well as *Entozoa*, and *on the former, again, other parasites have been observed.* 11. They are,

in general, affected by external agents, much in the same manner as the larger organic beings. 12. The microscopic *animalcula* being extremely light, they are elevated by the weakest currents, and often carried into the atmosphere. 13. Those observers who think they have seen how these minute creatures suddenly spring from inert matter, have altogether overlooked their complicated structure. 14. It has been found possible to refer to certain limits or organic laws, the wonderful and constant changes of form which some of these *animalcula* present. 15. That the organism of these *animalcula* is comparatively powerful, is evinced by the strength of their teeth and of their apparatus for mastication; they are also possessed of the same mental faculties as other animals. 16. The observation of these microscopic beings has led to a more precise definition of what constitutes an animal, as distinct from plants, in making us better acquainted with the systems of which the latter are destitute—*W. W.—Weimar.*

20. *Meeting of the British Association for the Advancement of Science.*—Just as this No. was closing, we have received the following important communications, to which by request, we give immediate insertion.

1. *Letter from* Roderick Impey Murchison, Esq., to Prof. Silliman.

London, 16 Belgrave Square, Feb. 24, 1840.

My dear Professor—I enclose herewith an invitation to attend the next meeting of the British Association, to be held at Glasgow on the 17th of September next. The local authorities of that city, from whom this invitation is sent, wish you to be the organ, through your widely circulated and valuable Journal, of asking any Professors or cultivators of science in the different states of N. America, to honor us by being present at our next meeting.

I need hardly tell you who are so well versed in British geology, that Glasgow is peculiarly attractive to geologists, and that the Isle of Arran alone will afford much instruction in some of the most interesting pages of geological history.

As Senior General Secretary of the Association, I can assure you, that the greater the number of your countrymen, who may honor the meeting with their presence, the higher will be the gratification of the officers and council of our body, including yours, very faithfully,

Rod. I. Murchison.

2. *Circular of the British Association for the Advancement of Science, addressed to the gentlemen invited to attend its next meeting.*

Glasgow, 1st January, 1840.

Sir—We have the honor to announce, that the next meeting of the British Association for the Advancement of Science, takes place in

Glasgow, beginning on 17th September, 1840, and continues its sittings for one week. Actuated by the ambition to procure the countenance of your illustrious name, and the aid of your distinguished talents, as well as by the desire to confer on British men of science the highest gratification, the citizens of Glasgow have ventured to hope, that your engagements and convenience may permit you to do them the honor of visiting them on that occasion, and they beg to assure you of their best hospitality.

Should you feel at liberty to honor them in this manner, we respectfully solicit you to notify your intention by letter to the secretaries, previous to 1st July next, in order that due arrangements may be made for your reception.

We have the honor to be, Sir, your obedient servants,

HENRY DUNLOP, *Lord Provost of the City.*
D. MACFARLAN, *Principal, Univer. of Glasgow, V. P. British Association.*
J. P. NICHOL, ANDREW LIDDELL, JOHN STRANG, *Local Secretaries.*

3. *Letter to Prof.* SILLIMAN, *from one of the local secretaries.*

Sir—It has been suggested that instead of sending special invitations to the many scientific individuals, of which the United States of America can boast, that you would have the goodness to state in your widely circulating Journal, the fact that the British Association is to meet at Glasgow on the 17th Sept. next, and that the local committee would feel highly honored with the presence of as many of the men of science of America, as can make it convenient to attend. It is calculated that the coming meeting will be the largest that has ever taken place in Great Britain.

I am, Sir, your most obedient servant,

JOHN STRANG, *Secretary.*

4. *British Association for the Advancement of Science.*

Office-bearers for meeting at Glasgow, on Thursday, 17th September, 1840.

President.—The most noble the MARQUIS OF BREADALBANE.

Vice-Presidents.—The very Rev. PRINCIPAL MACFARLAN, LORD GREENOCK, SIR THOMAS M. BRISBANE, Bart., SIR DAVID BREWSTER.

General Secretaries.—R. I. MURCHISON, Esq., F. R. S., London, MAJOR SABINE, London.

Secretary to Council.—JAMES YATES, Esq., London, PROFESSOR PHILLIPS, York, *Assistant Secretary.*

Treasurer.—JOHN TAYLOR, Esq., London.

Local Secretaries.—Professor Nichol, LL. D., Andrew Liddell, Esq., John Strang, Esq.

Local Treasurer.—Charles Forbes, Esq., Banker.

Committees.—On finance.—The Hon. the Lord Provost, *Convener.* John Leadbetter, Esq., *Sub-Convener.* James M'Clelland, Esq., Accountant, *Secretary and Treasurer.*

To provide sectional and other accommodations.—Wm. Ramsay, Esq., Professor of Humanity, *Convener.* James Smith, Esq., Architect, *Sub-Convener.* Alex. M'Dowall, Esq., Writer, *Secretary.*

On exhibition of Models and Manufactures.—John Houldsworth, Esq., *Convener.* Wm. Hussey, Jun. Esq., *Sub-Convener.* James Thomson, Esq., C. E. *Secretary.*

On Museum of minerals found in the West of Scotland.—Thomas Edington, Esq., F. R. S. *Convener.* Wm. Murray, Esq. of Monkland, *Sub-Convener.* Dr. Wm. Couper, Professor of Natural History, *Curator.* Thomas Edington, Jun. Esq., *Secretary.*

5. *Classification of Rocks.—Extract of a letter from* R. I. Murchison, Esq., *to* Prof. Silliman, *dated London, Feb.* 24, 1840.

"In furtherance of the views which we propounded last year, of classifying the ancient rocks beneath the carboniferous system into three great systems or terrains, "Devonian," "Silurian," and "Cambrian," Prof. Sedgwick and myself are about to read before the Geological Society of London a memoir, in which we endeavor to show the true succession of these strata in the Rhenish provinces, parts of Germany, Belgium, &c., and their relations to our British rocks. I am most impatient to test the value of this classification in the United States, but a year at least must elapse before I can think of an expedition to your shores. Complete suites of the fossils of the infra-carboniferous rocks would be most valuable to me, and most gladly repaid by a copy of my large work, or with Silurian fossils."

21. *On the action of Metallic Tin on solutions of Muriate of Tin;* by Augustus A. Hayes.

It has been long known to those who frequently dissolve tin in muriatic acid, that under some circumstances, the metal after it has been dissolved is precipitated. It sometimes presents large sections of octahedral crystals, at others, long prismatic needles, which are so arranged as to form skeletons of such sections. In this Journal, Vol. xxvii, p. 255, Mr. W. W. Mather has described some experiments having a similar result. The interest which has been excited of late by notices of the non-action of metals in acid solutions and in relation to chemical action of a similar kind, has induced me to publish the facts which I sometime since observed.

When tin is dissolved in muriatic acid, either by gradual action under exposure to air, or by the aid of heat, a solution containing an excess of acid is obtained. This solution may be concentrated to a sp. gr.=1.750, and retains its fluid form at or above 60° F. Although an excess of tin is present, the solution thus obtained is always acid. After decanting the clear solution, the tin used in excess with its impurities remains. Generally, after a few days exposure, the matters left in the solution vessel change in appearance. The dull, corroded fragments of metal become frosted over, with bright needles of tin, and beautiful arborescent forms are seen. On studying the circumstances, I have found that the effect is due to electrical action. One portion of the undissolved tin, becoming a *positive* electrode, while another portion of the same mass assumes the state of a *negative* electrode, and precipitation of the dissolved tin takes place on it. Numerous cases of like action are known to chemists, where a part of a bar becomes indifferent to a concentrated solution, although a positive state is exhibited at another part, and active sulution of the metal is taking place.

For the purposes of experiment, a solution of muriate of tin, of sp. gr. about 1.650, contained in a cylindrical vessel, may be carefully covered by half its volume of an acid solution of the same, having a sp. gr. about 1.20. The two fluids should not be mixed more than the slight diffusion which will take place. After placing a flat bar or plate in an inclined position, so that it passes through both solutions, the effects become immediately perceptible. That part of the bar which is within the diluted solution takes the *positive* state. A few minute bubbles of hydrogen form and escape, if the solution is quite acid. Precipitation of metallic tin commences near the line of contact of the two solutions, and extends throughout that part of the bar immersed in the denser solution. If the diluted solution is not rendered acid by the addition of acid, hydrogen is not perceived, and the action is more gradual. In either case the precipitation continues until the two fluids have attained the same electrical relation to the bar. If after the precipitation has ceased, water be carefully poured upon the surface of the fluid, it will form a stratum of very dilute solution. That part of the bar not before immersed takes the negative relation to this solution, and the same kind of precipitation follows as had taken place in the lower solution. The positive part of the bar, retains its state unaltered under the new conditions, and the line of separation is as clearly defined as in the first case. If a solution mixed with crystals be used, instead of a moderately concentrated solution, they are not decomposed under the above conditions. The presence of atmospheric oxygen has been supposed to influence

this action. Such is not a correct statement; by exposure to atmospheric vapor, strong solutions of muriate of tin become weaker, and any masses of undissolved tin, projecting into the weaker solution, will decompose the denser solution below. In numerous trials, I have found all the cases of precipitation referable to different states of two solutions resting in contact.

Roxbury Laboratory, March 16, 1840.

22. *New Minerals.*—Associated with the nitrate of soda of the province of Tarapuca, I have found the iodate of soda or potash, in irregular crystalline grains. The chloriodate of magnesia, in the state of solution, colors parts of the masses of the nitrate of soda a lemon yellow color. This new salt, doubtless, exists in mineral waters, conferring its highly active properties on them. The so called sulphate of alumina, from near Iquque, is a new mineral species, composed essentially of sulphuric and phosphoric acids, alumina and magnesia. It is entirely soluble in a small proportion of water, and is one of the most beautiful of saline minerals. Borate of magnesia, containing a larger than usual proportion of water under a different crystalline form, is found in the vicinity of the latter. A. A. Hayes.

March 16, 1840.

23. *An additional fact illustrating the inferior surface of the Calymene Bufo;* by Prof. Jacob Green, M. D.—In one of the recent numbers of your valuable Journal, there were published a few facts, which I had been so fortunate as to collect respecting the structure of the inferior surface of the trilobite. The *Calymene Bufo* was the species to which most of my remarks applied. The following additional note will perhaps be interesting to some of your readers.

Within a few days I received from my friend, Mr. T. A. Conrad, the zealous and distinguished fossilist of the New York survey, three highly interesting fragments of the *C. Bufo*, which develop a small portion of its anatomical structure not heretofore observed. In my former communication above noticed, the following statement will be found. "None of our fragments exhibit fairly the small surface on each side of the *gullar plate*, and the edge of the buckler beneath the eyes. This space was probably concave," &c. Now the fragments of Mr. Conrad illustrate this part of the organization in quite a satisfactory manner. This space is concave, and the edge of the buckler beneath the eyes, which in one of the specimens is very perfect, is marked by six denticulations or tooth-like prominences along the inferior edge of the lower lip. The lower lip has therefore a smooth or unbroken edge in front, and is terminated on each side below the eyes by a denticulated margin.

In no instance have I seen the interior edge of the buckler so perfect as in one of the above specimens, and in looking at the groove which forms the lips, one is almost persuaded to believe that the mouth of the animal was really located in this part of the head.

Index photographed at the
beginning for the convenience
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